Established by BENJAMIN SILLIMAN in 1818.

THE

AMERICAN JOURNAL OF SCIENCE.

EDITOR: EDWARD S. DANA.

ASSOCIATE EDITORS

PROFESSORS GEO. L. GOODALE, JOHN TROWBRIDGE, H. P. BOWDITCH AND W. G. FARLOW, OF CAMBRIDGE,

PROFESSORS A. E. VERRILL, HENRY S. WILLIAMS, AND L. V. PIRSSON, OF NEW HAVEN,

PROFESSOR GEORGE F. BARKER, OF PHILADELPHIA,
PROFESSOR H. A. ROWLAND, OF BALTIMORE,
MR. J. S. DILLER, OF WASHINGTON.

FOURTH SERIES.

VOL. VIII—[WHOLE NUMBER, CLVIII.]

No. 46.—OCTOBER, 1899.

PLATE V.

NEW HAVEN, CONNECTICUT.

1899.

TUTTLE, MOREHOUSE & TAYLOR, PRINTERS, 125 TEMPLE STREET.

Published monthly. Six dollars per year (postage prepaid). $6.40 to foreign subscribers of countries in the Postal Union. Remittances should be made either by money orders, registered letters, or bank checks.

JAPAN AND AUSTRALIA.

Large shipments lately arrived have excited unusual interest, as testified by the number of telegraphic orders received.

JAPAN.—Our agent in Japan obtained for us many typical well known species and at a sufficiently low figure to permit inviting prices to our customers. Below we mention a few of the more important.

ZEOLITES: Heulandite, Apophyllite, Analcite.

QUARTZ: Smoky, Amethyst, Chalcedony.

STIBNITE! RHODOCHROSITE! TOPAZ. ANORTHITE. ORTHOCLASE. EPIDOTE.

AUSTRALIA.—The following are worthy of separate description, though other notable species are only named in this limited space.

Opals. One of the newly opened opal fields in N. S. W. was visited by our collector, and an astonishing variety of layer opal obtained. The rainbow combinations with white cloud effects leaves one amazed and bewildered! Prices up to twenty dollars.

Special attention is called to a unique and valuable "opal pseudomorph, probably after an orthorhombic mineral" (Penfield).

Precious Opal in a curious association with opalized wood. A new occurrence. Prices range between 50c. and $4.00.

Marshite. This rarity can now be furnished in distinct crystallizations, needing no lens to disclose them. "Too few to go 'round," with prices from $4.00 upwards.

Stolzite and Raspite. Two of the rarest of lead compounds, both tungstates, but of different crystallization. Our *present* assortment of both species is without rival, but they will vanish promptly as did the former lot. Prices for good specimens, from two to ten dollars; better may be had at higher figures.

Golden Anglesite. Nothing finer for color or brilliancy to be found under this species. They must be seen to be fully appreciated. Prices from 75c. to $10.00; a few higher.

Pyromorphite, large and well terminated. You might think it from Ems but for the odd variations.

Cerussite, in twin crystals and reticulated masses.

Copper, carbonates and native, including gemmy little Azurite crystals.

Chalcedony, from Kerguelen Island, South Indian Ocean. 25c. to $1.00.

Rutile, in separate crystals of remarkable symmetry and perfection. Not large, but of good quality, bright faces and varied habits. Individual crystals from 15c. to $1.50. Selected suites of four, at $1.75 to $3.75.

FRANKLIN'S NEW SPECIES.

Mineralogists were again surprised when announcement was made of the new species discovered at the old locality. We have been holding sale on these interesting compounds for several months pending description published by Professor Penfield and Mr. Warren in "*Dana's First Appendix*," and are pleased to offer the following rarities in typical specimens.

Nasonite, another lead silicate, massive, but readily recognized. We have few specimens and can't get more, so your order should be filed at once. Prices from $2.00 to $8.00.

Glaucochroite, $CaMnSiO_4$. Distinct crystals in several instances, but extremely rare. The mineral was sparingly found and commands a high price.

Hardystonite. Announced by Professor Wolff. Distinct crystals though rough are rare. The massive mineral is the cheapest new species we have ever placed on the market; 50c. to $2 00.

Hancockite, both crystallized and massive, the former associated with brilliant Axinite. Prices from 50c. to $7.00.

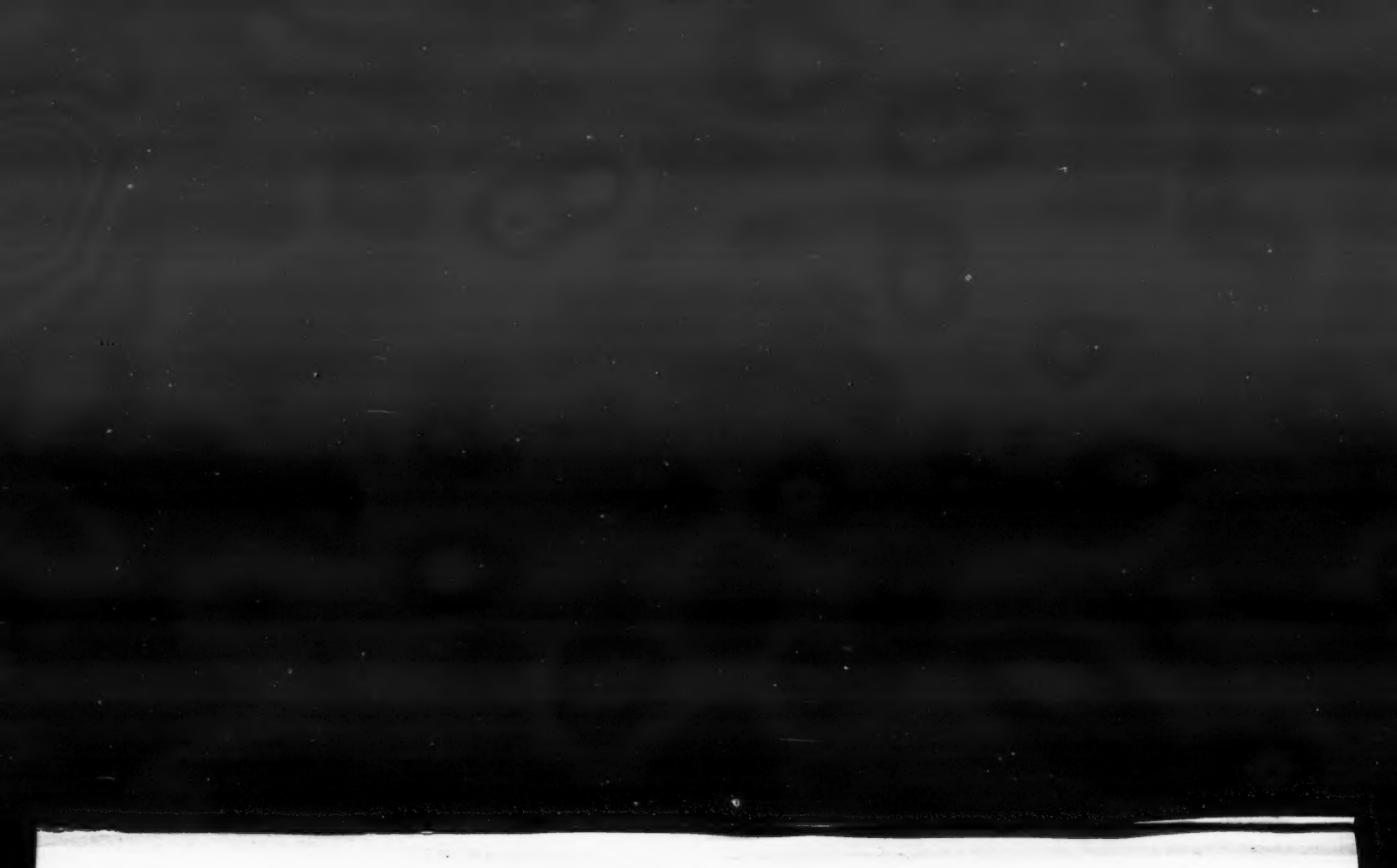
School and Academy Collections.
Crystals. Laboratory Material.

Dr. A. E. FOOTE,

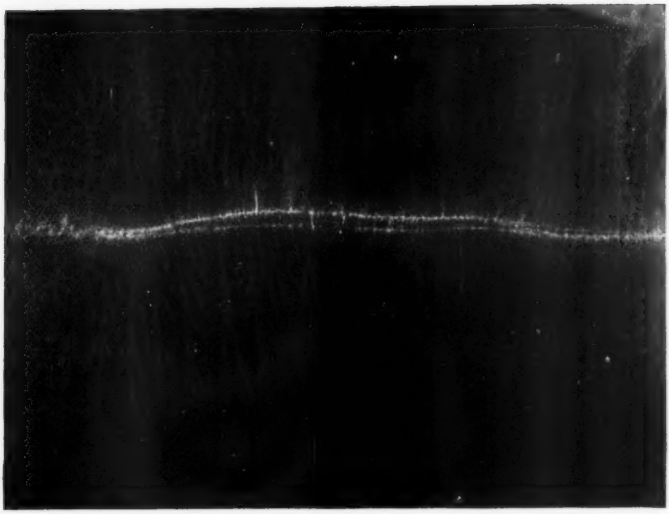
WARREN M. FOOTE, Manager.

1317 Arch Street, Philadelphia, Pa.; U. S. A.

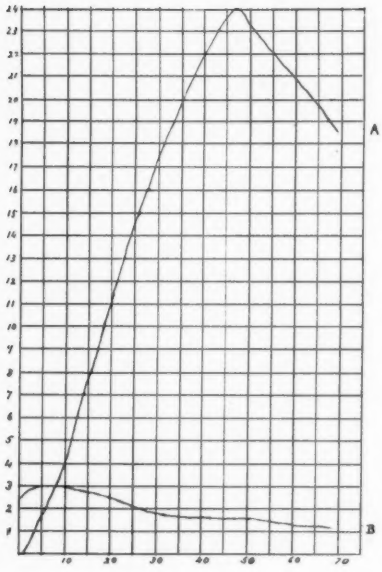
ESTABLISHED 1876.



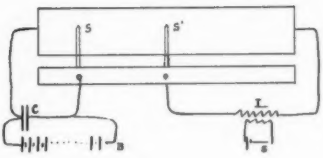
1



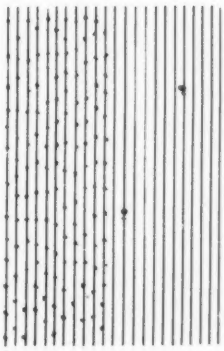
2



3



4



THE

AMERICAN JOURNAL OF SCIENCE

[FOURTH SERIES.]

ART. XXVI.—*Explosive effect of Electrical Discharges;* by JOHN TROWBRIDGE, T. C. MCKAY and J. C. HOWE. With Plate V.

SINCE the time of Franklin the subject of the explosive effect of electrical discharges has been studied by numerous investigators, and an extended bibliography of their work is contained in Wiedemann's "Galvanismus und Electromagnetismus."

The resources of the Jefferson Physical Laboratory permitting the study of this phenomenon over greater range than has hitherto been possible, we have undertaken the work in the hope of further elucidating the subject. The laboratory possesses two high tension transformers or Planté rheostatic machines—one giving discharges of 125 centimeters in length, and one yielding sparks 180 to 200 centimeters in length. These transformers are connected to a battery of ten thousand cells, and can yield voltages from twenty thousand to three million. Various methods of measurement were tried. On account of the great tension all galvanometric and electrometric means had to be abandoned; and what is known as the electric thermometer was finally adopted. This consists, as is well known, of a hermetically closed glass tube, provided with a manometer gauge. The electrical discharge passes through the tube by means of a fine wire, or by a spark gap. The term electrical thermometer is a misleading one; for as we shall show, the quick movement of the manometer gauge is not due to heat.

At first we passed the discharges through very fine wire. The gauge, which consisted of a bent glass tube containing an

index of bichromate of potash, rose suddenly at each discharge and returned approximately to the zero point. When, however, the wire had been heated by repeated discharges, the index showed a slow rise in temperature. Even when the terminals in the glass tube were connected by a fine wire, a very strong electrostatic field was created in the tube. This is shown in an interesting manner by fig. 1 (Plate V). This photograph was obtained by stretching a fine wire over a photographic plate and sending a single discharge through the wire, there being no spark gap in the circuit. The fine wire vibrated during the discharge; and when the negative thus obtained was closely examined, subsidiary vibrations were shown by many black lines approximately parallel to each other. These lines were apparently caused by the heat of the discharge melting the gelatine where the wire came in close contact with the film. The electrostatic field about the wire is exhibited by a fern-like discharge at right angles to the wire.

We were soon convinced that heat played a subordinate part in the phenomenon shown by the quick rise of the manometer index. This rise was apparently dependent upon the electrostatic conditions rather than upon thermodynamic or magnetic phenomena. We, therefore, abandoned the fine wire connection and employed a spark gap having a range from zero to eighty centimeters. It was possible to still further extend this range to two hundred centimeters; but it was found that the range from zero to eighty centimeters exhibited the main features of the phenomenon. The following table gives the results obtained with discharges produced by three million volts, 10,000 Planté cells, 150 condensers, charged in multiple and discharged in series; pointed brass terminals in large glass cylinder; gauge consisting of a bent glass tube with a potassium bichromate index; R_1 and R_2, readings of gauge before and after discharge; D, difference of these readings in centimeters; F, distance between terminals.

It will be seen from the curve A, fig. 2, that the explosive effect increases closely proportional to the length of the spark until the length of fifty centimeters is reached. It then begins to diminish. This decrease occurs with the increase of electrostatic effect in the field surrounding the spark gap,—or in other words, with the divergence or spreading of the electric lines of force. The electrostatic effect in this field, when a difference of potential of three million volts is generated, is very great. Sparks can be drawn from neighboring objects. Shocks are felt when the observers touch each other; and photographic plates, shielded from light in plate holders, held at distances of five or six feet from the terminals, exhibited, on development, brush discharges, or Lichtenberg figures.

F	R_1	R_2	D	Average.
10	4·4	4·9	·5	
"	4·6	5·0	·4	0·45
17	4·5	5·5	1·0	
"	4·7	5·2	·5	
"	4·8	5·5	·7	
"	5·0	6·2	1·2	0·9
24	4·7	6·0	1·3	
"	5·	6·2	1·2	
"	5·3	6·5	1·2	1·2
31	4·8	6·7	1·9	
"	4·8	6·6	1·8	
"	5·4	7·2	1·8	1·8

F	R_1	R_2	D	Average.
38	4·7	6·7	2·0	
"	5·1	7·3	2·2	
"	5·5	7·7	2·2	2·1
46	4·8	7·2	2·4	
"	5·3	7·7	2·4	
"	5·5	7·9	2·4	
				2·4
53	5·1	7·3	2·2	
"	5·4	7·7	2·3	
"	5·6	7·3	2·7	
"	5·2	7·1	1·9	
"	5·4	7·5	2·1	2·2
60	4·7	6·2	1·5	
"	5·7	7·3	1·6	
"	5·4	7·6	2·2	
"	5·5	8·1	2·6	
"	5·2	7·1	1·9	
"	5·2	7·6	2·4	
"	5·2	7·5	2·3	2·1
67	4·8	7·0	2·2	
"	5·1	7·1	2·0	
"	5·3	7·3	2·0	
"	5·5	6·7	1·2	
"	5·2	7·1	1·9	
"	5·4	7·3	1·9	
"	5·5	7·6	2·1	1·9
74	4·8	6·4	1·6	
"	5·1	6·6	1·5	
"	5·3	6·9	1·5	
"	5·3	7·3	2·0	
"	5·4	7·2	1·8	
"	5·5	7·3	1·8	1·7
80	4·8	5·2	·4	
"	4·5	6·3	1·8	
"	5·0	5·9	·9	
"	5·1	5·4	·3	1·1

The measurements were next repeated, while, at the same time, spark discharges were measured in a transformer circuit, the primary of which was in the circuit of the high tension transformer or Planté machine. In the following table column A contains the length of spark in the primary circuit, or circuit of the Planté machine; column B, the length of spark in the secondary coil circuit.

A	B	A	B
0	2·5	14	3·0
1	2·7	16	2·8
2	3·0	20	2·6
3	3·0	30	1·7
4	3·0	40	1·8
5	3·0	50	1·6
6	3·2	60	1·3
7	3·3	70	1·2
		80	1·2
			1·

When these results are plotted the lower curve, B, fig. 2, shows that the spark-length in the secondary circuit increases while the primary spark-length is increased up to seven centimeters. When, however, the primary spark-length is increased to fourteen centimeters, the length of the secondary spark begins to diminish. Thus the maximum of the curve B is a little in advance of the minimum of the curve representing the explosive action. Since the magnetic flux through the little transformer is proportional to the strength of the current in the primary circuit, it is seen that the explosive effect is not due to the heat produced by the current. Previous experiments by one of us had shown* that the apparent resistance of the primary spark did not increase with the length of the spark. The diminution in magnetic flux is due not to increase of resistance in the primary circuit but to a shunting through the air of the current in this circuit. Fig. 1 shows how great this shunting action can be even with closed circuits under the action of high electromotive force. The explosive effect, therefore, we are inclined to attribute primarily to an electrostatic action. When the primary spark gap is small, a silent discharge lowers the difference of potential between the spark terminals. As the distance between these terminals increases, the silent discharge diminishes, and the difference of potential increases until a point is reached at which strong inductive efforts take place between all surrounding objects.

The energy of the electrostatic field thus manifests itself by what we may, perhaps, term an ionization and electrical attraction and repulsion of the particles of the air. This electrostatic action does not extend to the great distances reached by the electromagnetic effect of the field. While the latter can be detected many miles, the electrostatic effect is confined to a few feet. Thus a spark of six or seven feet in length (180 to 210 centimeters) is vastly inferior to one of two or three inches (5 to 7·5 centimeters) for the purposes of wireless telegraphy. In experiments with electric waves by means of coherers we

* Proc. American Academy of Arts and Sciences, vol. xxxiii, No. 24.

found that the electrostatic effect was very disturbing up to a distance of twenty feet from the spark terminals, when these terminals were six feet apart. The disturbance diminished as the terminals were brought nearer together. The minimum of the curve representing this disturbance coincided with the minimum of the curve representing the explosive effect. On the other hand, the action of the magnetic waves on the coherer becomes regular beyond a distance of about twenty feet.

The electrostatic effect is evidently some function of the electrical density on the terminals of the spark gap and on the coatings of the condenser. The following experiments illustrate this dependence of the sparking distance upon this density. A chronograph cylinder was provided with two pointers S and S', fig. 3, one of which was connected to one coating of a condenser C, while the other coating of the condenser was joined to the metal cylinder of the chronograph. The coatings of the condenser were charged through an adjustable very large liquid resistance by means of ten thousand cells B. The other pointer was connected with one terminal of a small Ruhmkorff coil I, while the other terminal wire of the coil was led to the cylinder of the chronograph. The primary of the Ruhmkorff coil was interrupted by a second pendulum which broke the circuit at S. The pointers were placed on a carriage. When this was released, the pointers drew lines on blackened paper, fig. 4, placed upon the chronograph cylinder; and the number of the discharges of the condenser in one second could be estimated. With small resistance between the battery and the plates of the condenser the number of discharges in a second was very great. This number decreased as the resistance increased, and was approximately inversely proportional to this resistance. The condensers were of glass, of rubber, and an air condenser was also employed. In every case the number of discharges was inversely proportional to the resistance between one plate of the condenser and the battery.

Since the frequency of the discharge of the condenser depended upon the resistance between one plate of the condenser and the battery, it was evident that the energy of the battery was employed to charge the condenser to a sufficient surface density to enable a spark to be formed. A portion of this energy was wasted. This silent discharge can be regarded as a species of ionization. The condenser with its terminals forms a species of voltaic cell with a phenomenon of polarization. If the capacity of the condenser was increased, the effect was the same as that produced by increasing the resistance, as far as diminishing the number of discharges in a second. The energy of each discharge in this case was not

similarly diminished, since the entire strength of the battery served to charge the condensers.

In the phenomenon of the explosion produced by electrical discharges we are, therefore, dealing with electrostatic effects rather than with heat phenomena; and very high potentials bring to light in a marked way the phenomena of the electrostatic field. With differences of potential above one million volts ordinary air becomes a fairly good conductor. The electric force diminishes much more rapidly with the distance than the magnetic force (shown by Hertz). Phenomena of light are produced in the electrostatic field; and there are movements of molecules which may be embraced under the broad term ionization.

We are, therefore, led to the following conclusions:

1. The explosive effect of electrical discharges is due to an electrostatic effect rather than to a heat effect.

2. A strong analogy exists between the terminal conditions existing in electrical discharges and those of the electrodes of an ordinary voltaic cell. The electrical density on the terminals of a condenser is proportional to the strength of current which the charging battery is capable of producing.

3. The electrostatic field, diminishing much more rapidly with the distance than the electromagnetic field, doubtless has its energy consumed in molecular movements.

Jefferson Physical Laboratory,
Harvard University, U. S.

ART. XXVII.—*Experiments relative to the Constitution of Pectolite, Pyrophyllite, Calamine, and Analcite;* by F. W. CLARKE and GEORGE STEIGER.

IN a series of investigations by Clarke and Schneider which were carried out in the laboratory of the United States Geological Survey between 1889 and 1892,* a number of reactions were examined which shed some light upon the constitution of several natural silicates. The work then begun was unfortunately interrupted for several years; but it is now resumed, with the hope that it may be pushed considerably further.

Two of the reactions studied by Clarke and Schneider were of peculiar interest. First, in the case of talc, it was found that one-fourth of the silica could be liberated by ignition; and that the fraction thus set free was measurable by solution in aqueous sodium carbonate. This reaction suggests that other acid metasilicates may behave in a similar way, and that we perhaps have a means of discrimination between such salts and other compounds which simulate them. In other words, an acid metasilicate may be experimentally distinguished from a pseudo-metasilicate by the way in which it splits up when ignited. Evidence bearing upon this supposition will be found in the present paper.

The second of the reactions just referred to is that between dry ammonium chloride, at its temperature of dissociation, and various silicates.† This involves, in part at least, the action of dry gaseous hydrochloric acid upon the compounds which are studied; and different minerals are very differently attacked. Some are almost completely decomposed, others are affected but slightly; and here again there seems to be a method of diagnosis which deserves further attention. Both reactions suggest the main purpose of the investigation; which is, the fractional analysis of silicates by means of various reagents, in order to gain evidence bearing upon their chemical structure. The evidence at least is of value, whether the interpretation of it be right or wrong. Each fact helps to the ultimate solution of the central problem, the problem of constitution.

Pectolite.

The pectolite which was chosen for examination was the well-known radiated variety from Bergen Hill, N. J. The mineral was in long white needles, and apparently quite pure;

* This Journal, III, vol. xl, pp. 303, 405, 452; vol. xlii, p. 242; vol. xliii, p. 378.
† Bulletin No. 113, U. S. Geological Survey, p. 34.

but the analysis shows that it contained some carbonate as an impurity. Enough of the material was ground up to furnish a uniform sample for the entire series of experiments, and the work properly began with a complete analysis. The results obtained are as follows:

	Analysis.
SiO_2	53·34
Al_2O_3	·33
CaO	33·23
MnO	·45
Na_2O	9·11
Total H_2O	2·97
CO_2	·67
	100·10

Fractional water.	
Water at 105°	0·27
" " 180°	0·16
" " 300°	0·22
" " redness	2·32
	2·97

All of the water was given off at a barely visible red heat; and the figures show that practically all of it is constitutional; a fact which perhaps hardly needed reverification. The analysis gives the accepted formula for pectolite,

$$HNaCa_2Si_3O_9.$$

Does this represent, as is commonly assumed, a true metasilicate? If it does, we should expect that ignition would split off silica proportional to the acid hydrogen, or one-sixth of the total amount. To answer this question several portions of the pectolite were sharply ignited, to complete dehydration, and then boiled each for fifteen minutes with a solution of sodium carbonate containing 250 grams to the liter. In the extract so obtained the silica was determined; and three experiments gave the following percentages:

	8·96
	8·67
	8·42
Mean,	8·68

One-sixth of the total silica is 8·89 per cent; and the experiments, therefore, justify the original expectation. The belief that pectolite is a metasilicate is effectively confirmed.

Upon the unignited pectolite the sodium carbonate solution has a slow decomposing action, both silica and bases being withdrawn. In two experiments fifteen minutes of boiling extracted 2·07 and 2·55 per cent of silica, and by a treatment lasting four days 4·80 per cent was taken out. With water alone similar results were obtained; the action being so rapid, although relatively slight, that pectolite, moistened, gives an immediate and deep coloration with phenol phthalein. By

boiling the powdered pectolite with distilled water alone, 1·65 per cent of silica was brought into solution, and the ignited mineral, similarly treated for fifteen minutes, gave 1·78 per cent. The extraction in these cases is really an extraction of alkaline silicate; as the two following experiments prove. In A the unignited pectolite was boiled for fourteen hours with distilled water; and in B the mineral after ignition was subjected to like treatment for four hours. The dissolved matter in each case was determined, with the subjoined results:

Extracted.	A.	B.
SiO_2	2·98	3·03
CaO	·30	·10
Na_2O	·81	1·50
	4·09	4·63

In A, no simple ratio appears; but in B the extracted silicate approximates very nearly to the salt $Na_2Si_2O_5$. In each instance the ratios vary widely from those of the original mineral, showing that actual decomposition and not a solution of the pectolite as such has occurred.

In the experiments upon pectolite the heating with dry ammonium chloride was omitted, for the data are already given in the original paper by Schneider and Clarke. In their experiments the mineral was thrice heated with ten times its weight of the reagent to above 350°, and then leached out with water. In the solution 20·50 per cent of lime and 6·95 of soda were found, with part of the manganese; showing that a very considerable decomposition had taken place. Possibly, by repeated treatments with ammonium chloride a complete decomposition might be effected; but this question is one upon which it seemed unnecessary to spend further time.

Pyrophyllite.

The empirical formula for pyrophyllite, $AlHSi_2O_6$ is apparently that of an acid metasilicate, and the mineral is therefore peculiarly available for fractional analysis. The compact variety from Deep River, N. C., was taken for examination, and a uniform sample was prepared. Analysis gave the following results:

SiO_2	64·73
TiO_2	·73
Al_2O_3	29·16
Fe_2O_3	·49
MgO	trace
Ignition	5·35
	100·46

If now, pyrophyllite is an acid metasilicate it should break up on ignition in accordance with the equation

$$2AlHSi_2O_6 = Al_2Si_3O_9 + SiO_2 + H_2O.$$

That is, one-fourth of the silica, or 16·18 per cent, should be liberated. The mineral itself is very slightly attacked by boiling with the sodium carbonate solution, and in an experiment of this kind only 0·72 per cent of silica was dissolved. Upon ignition under varying circumstances the following data were obtained:

Ignited ten minutes over a Bunsen burner, and then extracted with sodium carbonate solution, 1·51 per cent of SiO_2 dissolved.

Ignited fifteen minutes over a Bunsen burner, 1·89 per cent became soluble.

Ignited ten minutes over a Bunsen burner and then fifteen minutes over the blast, 2·84 per cent of silica was liberated.

These results are of a different order from those given by pectolite and talc, and raise the question whether pyrophyllite, despite its ratios, is a metasilicate at all. So far as the evidence goes, it may with propriety be regarded as a basic salt of the acid $H_2Si_2O_5$, and its formula then becomes

$$Si_2O_5 = Al-OH.$$

This formula is at least as probable as the metasilicate expression, which latter rests upon assumption alone. Still other formulæ, but of greater complexity, are possible; but until we know more of the genesis and chemical relationships of pyrophyllite, speculation concerning them would be unprofitable.

By heating with dry ammonium chloride, pyrophyllite is very slightly attacked. In two experiments it lost in weight 6·17 and 6·30 per cent respectively. The excess of loss over water is due, as we have proved, to the volatilization of a little ferric and aluminic chloride. The residue of the mineral after this treatment contained no chlorine, so that no chlorhydrin-like body had been formed. The formation of such a compound, the replacement of hydroxyl by chlorine, would, if it could be effected, be a valuable datum towards determining the actual constitution of the species.

Calamine.

The simplest constitutional formula for calamine, the one which is generally accepted, represents it as a basic metasilicate, $SiO_2=(ZnOH)_2$. In this the hydrogen is all combined in one way, and so, too, is the zinc. In all other possible formulæ,

simple or complex, the hydrogen as well as the zinc must be represented as present in at least two modes of combination; a condition of which, if it exists, some evidence should be attainable. Our experiments upon calamine have had this point in view; and we have sought to ascertain whether water or zinc could be split off in separately recognizable fractions. Our results, in the main, have been negative, and tend towards the support of the usual formula; but the data are not conclusive, although they seem to be worthy of record.

The beautiful, white calamine from Franklin, N. J., was selected for study, and gave the subjoined composition:

	Analysis.
SiO_2	24·15
Al_2O_3, Fe_2O_3	·19
ZnO	67·55
CaO	·12
H_2O	7·95
	99·96

Fractional water.	
At 100°	·27
" 180°	·22
" 250°	·75
" 300°	·88
Incipient red heat	4·46
Full red heat	1·37
	7·95

Here no clear and definite fractionation of the water is recognizable, at least of such a character as to suggest any other than the ordinary formula for calamine.

Upon boiling powdered calamine with water, practically nothing went into solution, but by boiling with the solution of sodium carbonate, 0·25 cent of silica was dissolved. After ignition at a red heat, only 0·14 per cent of silica became soluble in sodium carbonate, and after blasting, only 0·24. In these experiments a very little zinc was dissolved also; but there was no evidence that any breaking up of the mineral into distinguishable fractions had occurred. In a hot ten per cent solution of caustic soda both the fresh and the ignited calamine dissolve almost completely; but boiling with aqueous ammonia seems to leave the mineral practically unattacked. All experiments aiming to extract a definite fraction of zinc while leaving a similar fraction behind, resulted negatively.

By heating with dry ammonium chloride, calamine is vigorously attacked, and gains in weight by absorption of chlorine. In two experiments the mineral was intimately mixed with three times its weight of powdered salammoniac, and heated in an air-bath for several hours to a temperature somewhat over 400°. A large part of the residue was soluble in water, and the percentage of this portion, together with the percentage increase in weight, is given below.

	I.	II.
Gain in weight	27·60	25·78
Soluble in water	53·23	67·13

A conversion of calamine into the chlorhydrin, $SiO_3(ZnCl)_2$, would involve a gain in weight of 15·34 per cent. Complete conversion into $2ZnCl_2+SiO_2$ implies an increase of 38·14 per cent. The figures given lie between these two; and are indefinite also for the reason that there was volatilization of zinc chloride.

In two more experiments the calamine, mingled with three times and four times its weight of ammonium chloride respectively, was heated for an hour and a half to bright redness in a combustion tube. The zinc chloride which was formed, volatilized, and was collected by suitable means for determination. It corresponded to 59·6 and 59·0 per cent of the original mineral, calculated as zinc oxide; which indicates a nearly complete decomposition of the calamine into $2ZnCl_2+SiO_2$. The residue was mainly silica, with a small part of the zinc, about half of the silica being soluble in sodium carbonate solution. Here again no definite fractionation of the mineral could be observed.

Finally the action of dry hydrogen sulphide upon calamine was investigated. The mineral was heated to redness in a current of the gas, and gained perceptibly in weight. The percentage data, reckoned on the original calamine, were as follows, in two experiments:

	I.	II.
Gain in weight	6·00	6·43
SiO_2 soluble in Na_2CO_3	16·45	20·95
Sulphur in residue	----	24·12

Complete conversion of calamine into $2ZnS+SiO_2$ implies a gain in weight of 5·80 per cent; and it is therefore evident from the figures of the second experiment that the limit of change was approached very nearly. The 24·12 of sulphur taken up is quite close to the 26·53 per cent which is required by theory. About eight-ninths of the calamine had undergone complete transformation. Again, no definite fractionation was detected.

The hydrogen sulphide reaction was examined still further with reference to the temperature at which it becomes effective. Even in the cold, calamine is slightly attacked by the gas, but its action is unimportant until the temperature of 400° is approximated. Then it becomes vigorous and the reaction goes on rapidly. A few experiments with willemite showed that it also was attacked by hydrogen sulphide, but less vigorously than calamine.

Analcite.

Analcite, from many points of view, is a species of peculiar interest, and of late years it has received a great deal of attention. Its formula may be written in various ways, especially as regards the interpretation of its one molecule of water; but evidence too often has yielded before pre-conceived opinion. Additional evidence is now available, partly from the experiments of Friedel, and partly from the data obtained during the present investigation.

The analcite examined by us was in well-developed crystals from Wasson's Bluff in Nova Scotia. A uniform sample was prepared, as usual, and the analysis, given below, is contrasted with the theoretical composition required by the accepted empirical formula $NaAlSi_2O_6 . H_2O$.

	Found.	Calculated.	Fractions of water.	
SiO_2	57·06	54·55	At 100°	·58
Al_2O_3	21·48	23·18	" 180°	1·16
Fe_2O_3	·13		" 260°	3·64
CaO	·16		" 300°	1·57
Na_2O	12·20	14·09	Low redness	1·90
H_2O at 100°	·58		Full redness	·11
" over 100°	8·38	8·18	Blast	none
	99·99	100·00		8·96

The fractional water determinations were made by heating in an air-bath to constant weight at each temperature up to 300°, and finally over the direct flame. The first fraction, at 100°, is evidently hygroscopic or extraneous water, which can be disregarded. The remainder of the water, 8·38 per cent, belongs to the species. The significance of the analytical figures will be considered later.

Upon boiling the powdered analcite with sodium carbonate solution, 250 grams to the liter as in all the preceding experiments, 0·73 per cent of silica was extracted. After ignition the mineral in two determinations yielded 1·46 and 1·38 per cent respectively. The splitting off of silica is therefore very slight; and one of the formulæ proposed by Doelter,* $Na_2Al_2Si_2O_8+2H_2SiO_3$ may be set aside as improbable. Metasilicic acid or an acid metasilicate can hardly be present in analcite; although the possibility of a neutral metasilicate, as indicated by the empirical formula, is not excluded. By Doelter's formula one-half of the silica ought to be removable.

Upon heating analcite with dry ammonium chloride, results of a remarkable character were obtained. Sodium chloride

* Neues Jahrb., 1890, i, 133.

was formed, which could be leached out by water and measured; while ammonia, free from chlorine, was retained by the residue to a notable and surprisingly stable degree. The experiments in detail were as follows:

A. Analcite, mixed with four times its weight of ammonium chloride, was heated for four hours to 350°. There was a gain in weight of 2·18 per cent, and 6·10 per cent of soda, or one-half of the total amount, was converted into NaCl, which was leached out by water, examined as to its purity, and weighed. In the residue 1·20 per cent of silica was extractable by sodium carbonate, showing that no more splitting off had occurred than was previously observed. The gain in weight, as will be seen from subsequent experiments, is due to the fact that all of the NH_4Cl had not been driven off; or else that more water was retained.

B. Analcite was ground up with four times its weight of NH_4Cl, heated for several hours, reground with another four-fold portion of chloride, and heated to 350° for 21 hours. Gain in weight, 0·08 per cent. 5·57 per cent of soda was extracted as chloride.

C. Analcite heated to 350° for 8 hours, with four times its weight of NH_4Cl. Loss of weight, 0·10 per cent.

D. Six grams of mineral and 28 of chloride, mixed by thorough grinding, was heated to 350° for 14 hours; then was reground with 28 grams of fresh NH_4Cl and heated for 35 hours. Loss of weight, 0·13 per cent. 5·07 per cent of soda was extracted as chloride; plus 0·14 of ammonium chloride unexpelled. 2·03 per cent of silica was rendered soluble in sodium carbonate.

So far, three facts are noticeable. First, the weight of the mineral after treatment is almost exactly the same as before; showing that gains and losses have balanced each other. Secondly, little silica has been split off. Thirdly, approximately, but not rigorously, one-half of the soda has been converted into NaCl. In A, it was exactly half; in the other experiments, a little less than half. Furthermore, in the sodium chloride dissolved out there is only a very little ammonium chloride, amounting at most to 0·14 per cent, calculated upon the weight of the original mineral.

In the residue of the analcite after extraction of sodium chloride, abundant ammonia can be detected, with either no chlorine or at most a doubtful trace. If, however, the unleached mineral, still retaining its sodium chloride, be heated strongly, say from 400° up to redness, NH_4Cl is regenerated and given off. Its absence, as such, both from the leach and the residue was repeatedly proved. The ammonia and water retained by the analcite after heating to 350° with ammonium

chloride were several times determined; and the following percentages, still reckoned on the original mineral, were found:

	NH_3.	H_2O.
In B	2·03	2·25
" C	2·19	2·00
" D	2·36	1·89
" "	2·35	----
" "	2·06	----
Mean	2·20	2·04

Correcting the ammonia for the 0·14 of NH_4Cl found in D, the mean value becomes 2·15. This permanent ammonia is not given off upon warming the material with caustic soda solution; and is therefore not present as a salt. The determinations of it were made by three distinct methods, and there is no possible doubt as to its presence and character.

The composition of the analcite after the treatment with ammonium chloride may now be considered, with the subjoined combination of the data. The NaCl in A, 11·50 per cent, was in material which had gained 2·18 per cent, and is subject to a correction which reduces the figure to 11·26. In B, C, and D the corresponding correction is so small that it may be neglected. The last column gives the composition of the leached residue, recalculated to 100 per cent, after deduction of NaCl and the soluble silica. The letters refer back to the several experiments, and the little iron is included with the alumina.

	A.	B.	C.	D.	Average.	Residue.
Sol SiO_2	1·20	----	----	2·03	1·61	----
Insol. SiO_2				54·96	54·96	62·59
Al_2O_3				21·37	21·37	24·34
CaO				·16	·16	·18
NaCl	11·26	10·50	----	9·57	10·44	----
Na_2O				7·12	7·12	8·11
NH_3	----	2·03	2·19	2·21	2·15	2·46
H_2O	----	2·25	2·00	1·89	2·04	2·32
				99·31	99·85	100·00

The analcite residue, like the original mineral, is completely decomposible by aqueous hydrochloric acid. It may be a mixture; but it seems more probable that it is a definite compound; for it approximates in composition to the formula

$$H_2Na_2Al_4Si_6O_{24} \cdot NH_3.$$

This represents a quadrupled analcite formula, in which half of the sodium is replaced by hydrogen, and with NH_3 in place of $4H_2O$. The analytical comparison is as follows:

	Found.	Calculated.
SiO_2	62·59	61·46
Al_2O_3	24·34	26·12
CaO	·18	----
Na_2O	8·11	7·94
H_2O	2·32	2·30
NH_3	2·46	2·18
	100·00	100·00

The agreement is not close, but it is close enough to be suggestive, and to indicate the character of the reaction which has taken place. It needs, however, verification by additional experiments upon other preparations, and upon analcite from other sources. In this connection it may be well to reiterate that the substance was prepared by very long heating at 350°, and is therefore stable at that temperature.

An interesting feature of these experiments is their harmony with the researches of G. Friedel,* who has shown that the water of zeolites may be replaced by ammonia and other substances, without change of the crystalline structure. In the case of analcite, ammonia was taken up to the extent of 2·04 per cent; or almost exactly the amount found in our analcite residue. The great difference between Friedel's method of experimentation and ours, renders the agreement all the more striking; and sustains our belief that the mineral and the residue are compounds of the same general order. We hope to continue our experiments and to extend our investigation to other zeolites.

If, now, analcite and its derivative, our analcite residue, are analogous compounds, the relation between them is expressed by these formulæ:

Analcite ..... $Na_4Al_4Si_8O_{24} . 4H_2O$.
Analcite residue ..... $H_2Na_2Al_4Si_8O_{24} . NH_3$.

That is, the minimum molecular weight assignable to analcite is represented by four times its empirical formula. Other interpretations of the evidence are possible, but this appears to be the simplest. The water of analcite, as Friedel has shown, must be regarded as water only, not as hydroxyl; for it can be expelled by heat without destruction of the crystalline nucleus, the anhydrous salt, and is taken up again from moist air.

* Bull. Soc. Min., xix, 94, 1896.

But whatever its mode of union may be, the amount of water corresponds to the simple molecular ratio which is indicated in the formula of the species. One molecule of analcite holds a certain definite number of water molecules; and Friedel's observations are not incompatible with the idea that these are retained with varying degrees of tenacity. This idea is suggested by the various series of fractionation experiments which have been made from time to time, by independent workers, even though the data are not by any means concordant. Thus Lepierre* found that half the water of analcite was driven off at or below 300°, the other half above 440°. In our own experiments three-fourths were expelled at 300°, the remaining fourth being held up to a much higher, but undetermined temperature. In both series the water fractions are representable by fourths; but Friedel's experiments† indicate a continuity of loss in weight of quite a dissimilar order. Friedel holds that all of the water fractionations heretofore made upon analcite are fallacious, and that no definite fractions can be identified, a conclusion strongly supported by his own data, even though the proof is not absolutely positive. The most that can be said is, that the weight of evidence, so far, is in favor of Friedel's contention, but that additional investigation is necessary in order to reconcile all discrepancies. The full significance of the water in analcite remains unknown.

In order to discuss the constitution of analcite, let us recur to the analysis of the mineral itself. It is at once evident from the comparison made on a preceding page that our sample of the mineral varies notably in composition from the requirements of theory. The silica is two and one-half per cent too high, while alumina and soda are correspondingly low. No probable impurity and no presumable errors of manipulation can amount for so great a divergence. If we consult other analyses, as we find them tabulated in manuals like those of Dana and of Hintze, we shall find other cases resembling this, and also examples of variation in the opposite direction, with silica low and an apparent excess of bases. Most analcite gives quite sharply the metasilicate ratios required by the accepted formula; but the variations from it are large enough, common enough and regular enough to command attention. The analyses are not all covered by the recognized theory; and the apparent irregularities are not fortuitous, but are systematic in character.

One explanation of the seeming anomalies is simple and clear. If analcite, instead of being a metasilicate, is really a

* Bull. Soc. Chim. (3), xv, 561, 1896.
† Bull. Soc. Min., xix, 363, 1896.

mixture of ortho- and trisilicate, then all of the analyses become intelligible. In most cases the two salts are commingled in the normal ratio of one to one; but in our analcite the trisilicate predominates, while in some other samples the orthosalt is in excess. All reduce alike to the simple expression

$$NaAlX \cdot H_2O,$$

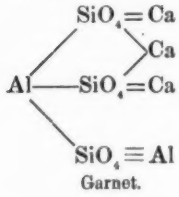
in which X represents $nSiO_4 + mSi_3O_8$; a formula which agrees with evidence from various other sources.

For example, analcite may be derived in nature either from albite, $AlNaSi_3O_8$, or nephelite, $AlNaSiO_4$, and on the other hand alterations of it into feldspars have been observed. Its closest analogue, leucite, has yielded pseudomorphs of orthoclase and elæolite; while leucite and analcite are mutually convertible each into the other. The evidence of this character, the evidence of relationship between analcite and other species, is varied and abundant; and the simplest conclusion to be drawn from it is that which has been given. Every alteration, every derivation, every variation in the composition of analcite, points to the same belief. The consistency of the data cannot well be denied.

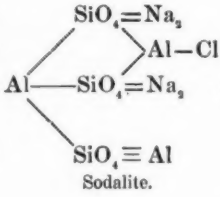
In the case of a normal analcite, that is, one which conforms to the usual empirical formula, the expression which best represents these relations is

$$Al_4Na_4(SiO_4)_3\,(Si_3O_8)_3 \cdot 4H_2O;$$

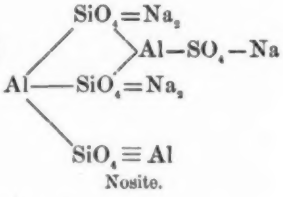
and this accords with the minimum molecular weight as determined by the study of our ammoniated residue. Structurally, this is comparable with the formulæ of garnet, zunyite, sodalite, nosite and leucite; all of which are also isometric in crystallization. The more important of the symbols are as follows:



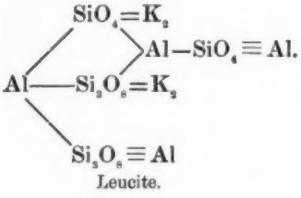
Garnet.



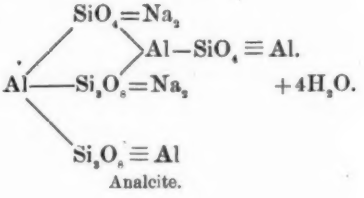
Sodalite.



Nosite.



Leucite.



Analcite.

That is, analcite and leucite become members of the garnet-sodalite group of minerals, and their relations to nephelite, albite, prehnite, natrolite, etc., natural and artificial, are perfectly clear. In analcite there may be admixtures of strictly analogous ortho- or trisilicate molecules; but these remain to be separately discovered.

Now these formulæ are not ultimate verities to be blindly accepted. They are simply expressions which represent composition and a wide range of established relationships, and which serve a distinct purpose in the correlation of our knowledge. Properly used, with due recognition of their limitations, they are helpful, and suggest possibilities of research; misused, they may become mischievous. They now satisfy all known conditions; and that is a sufficient warrant for their existence.

U. S. Geological Survey, July 1, 1899.

ART. XXVIII.—*On Color-vision and the Flicker Photometer;* by OGDEN N. ROOD, Professor of Physics in Columbia University. Part I.

IN the matter of color-vision, there seems to have been a tacit assumption that all persons could be divided into two classes, those with normal vision, and the color-blind. Holmgren's test with colored worsted classifies them in this way, and analogous tests give a like result. According to this view, the color-vision of persons free from color-blindness has generally been considered to be alike. Some time ago, for the purpose of comparing my own color-vision with that of others, an extensive set of experiments were made with the flicker photometer,* and while it turned out that not a single person agreed with *me*, it also was found that no two persons agreed with each other. These divergences were so large that it was impossible to attribute them to errors of observation, and the application to them of a control method showed them to have a real existence.

In making these determinations eleven persons were finally selected, most of them being young men, and all of them having claims to the possession of normal vision or varieties of it. Two were young women, and two, men in middle life. I started originally with fourteen persons, but was quickly obliged to reject three for previously unsuspected abnormality; two of these cases will be considered at the close of this article; the third, which is peculiar, is still under investigation. In comparing the eleven selected persons with myself, it was soon found that they could be divided into two classes with regard to their preception of green, five in one, six in the other, but as far as I could see, there was no especial reason for giving preference to one class above the other. It was accordingly decided to adopt the mean color-vision of the eleven, as representing, for the time being, standard human vision for color, and the divergence of each person from this standard was then calculated.

This standard color-vision is conveniently indicated by 100, in the cases of red, green and violet-blue light. 100 was also taken as the maximum attainable in each case, as these experiments did not deal with the general sensitiveness of the eye to light, but with its relative sensitiveness to light of different colors. That is to say, in the case of the color-curve of each person, the *highest* ordinate, whatever it may be, is set equal to 100, the others falling where the observations indicate on this assumption. Indeed there is no other way of making the

* See this Journal, Sept. 1899, p. 194.

calculations, without the aid of supplementary experiments of a totally different character. This much being premised, the tables given below will be intelligible. Classes A and B are given separately for the convenience of the reader, though as before said I do not know of any reason for giving preference to one over the other; indeed it will be noticed that they are more or less blended together by the cases of Wade, Parker and White.

Class A.

	Red.	Green.	Violet blue.
Wade	97·7	97·4	100·
Trowbridge	100·	91·6	95·6
Dr. Hallock	100·	90·9	96·2
Miss Furness	97·9	90·8	100·
Curtis	90·5	86·6	100·
Miss M	100·	81·6	99·

Class B.

	Red.	Green.	Violet blue.
White	96·1	100	95·8
Parker	95·7	100	95·8
Dr. Dennett	93·8	100	91·5
Dr. Tufts	89·9	100	87·8
Dr. Day	82·9	100	93·3

It may be remarked that all the persons above mentioned are unusually abstemious in the use of alcohol, tea, coffee, and tobacco, and the person who is most deficient in red does not use these articles at all.

It is true that the above results have been obtained by the aid of a standard derived from only eleven persons, all, apparently, with what has heretofore been called normal vision: of course it would be desirable to extend the observations to a larger number of persons, but in the meanwhile it is quite evident that the standard here adopted is considerably better than if one of the eleven had been selected, hap-hazard, as a representative of normal vision. It also follows that anyone of the eleven, when furnished with his curve, becomes a secondary standard, and can correct his observations till they are in accord with the standard here adopted. These results also make it evident, that no one, man or woman, is qualified to do reliable quantitative color-work until his or her color-vision has been tested as above indicated. Certain discrepancies in the older determinations may find here a partial explanation, the remainder, of course, being due to the employment of the older photometric methods.

Below are the results for three cases of red color-blindness,

two of which were not previously suspected. All three persons were quite unable to stand the Holmgren worsted test.

	Red.	Green.	Violet blue.
J. Alsberg	30·3	88·1	100·
Mr. W.	35·6	85·5	100·
Mr. O.	35·3	100·	93·9

Older persons appear to be more or less subject to another kind of defect in their color-vision, due, as Dr. Noyes suggests, to a yellow coloration of the crystalline lens. I have not studied the subject much, and can give the result of only one case: it was obtained by the use of the standard above described.

Red.	Green.	Violet blue.
100	77·2	72·

Art. XXIX.—*The Iodometric Determination of Gold;* by F. A. Gooch and Frederick H. Morley.

[Contributions from Kent Chemical Laboratory of Yale University—LXXXVIII.]

In a recent attempt to measure small amounts of gold in solution by titrating with sodium thiosulphate the iodine set free in the action of an excess of potassium iodide upon auric chloride, Peterson* has been led to conclude that, on the average, one-half more thiosulphate is used up in changing the characteristic starch iodide blue to the faint rose color which precedes entire bleaching than is called for upon the theory that the thiosulphate is simply converted to the tetrathionate in the usual manner. Peterson explains the anomaly upon the hypothesis that, besides acting upon the free iodine, the thiosulphate is used up coincidently by interaction with the aurous salt, formed in the reduction, with formation of a gold sodium thiosulphate on the type of the well-known silver sodium thiosulphate. The reaction of this hypothesis is in the nature of things most improbable, since there is no reason to suppose that the soluble double thiosulphate could resist the action of the free iodine which is present to the end—the appearance of the rose color,—and our study of the reaction of sodium thiosulphate upon the mixture of gold chloride and potassium iodide, the account of which follows, discloses no evidence of the consumption of more thiosulphate than is demanded by the usual theory, which postulates the simple formation of the tetrathionate by the interaction of the thiosulphate and free iodine.

It appeared in the course of our preliminary experimentation that, while practically similar results were obtained by adding the thiosulphate until the blue of the starch iodide had changed to rose, the indications were somewhat more concordant when the final rose color was developed by adding iodine to the solution from which the blue had been bleached to colorlessness by a slight excess of the thiosulphate.

It appeared, also, that the reduction of the auric salt, with the consequent liberation of iodine, is conditioned by the volume of the solution, the mass of the iodine present, and the time of action.

The following statement, in which each result is the average of several titrations in close agreement, shows the effect upon the immediate evolution of iodine brought about by adding varying amounts of water to the gold solution before introducing the iodide, and the effect of different amounts of iodide at different dilutions.

* Zeitschr für Anorg. Chem., xix, 63.

	Potassium iodide.					Gold chloride.	Volume before the addition of the thiosulphate.
	0·01 gm.	0·02 gm.	0·05 gm.	0·1 gm.	0·2 gm.	0·00087 gm.	cms.
Sodium thiosulphate, nearly $\frac{N}{100}$. cm³.	0·81	0·81	0·81	0·82	0·84	"	15
	0·77	0·78	0·80	0·81	0·81	"	25
	0·74	0·72	0·78	0·79	0·80	"	50
	0·61	0·61	0·68	0·76	0·79	"	100
	0·45	0·49	0·60	0·72	0·75	"	200

It is evident that for the smaller amounts of iodide the liberation of iodine decreases rapidly with the dilution. The larger amounts at the highest concentration show readings a trifle above the normal—perhaps because the well-known effect of concentrated solutions of a soluble iodide upon the delicacy of the starch end-color begins to appear. At volumes lying between the limit of 25$^{cm^3}$ and 50$^{cm^3}$ 0·1 grm. of potassium iodide is an appropriate amount to use; at a volume of 15$^{cm^3}$, 0·01 grm. to 0·05 grm. of the iodide will do the work; and at lower dilutions, as will appear in the tabular statements to follow, even less of the iodide is effective.

In the series of experiments of which the details are given in Table I, use was made of a solution of pure gold chloride containing 0·8710 grm. to the liter—as determined by careful precipitation in the usual manner by ferrous sulphate, and by an alkaline solution of formaldehyde according to the method of Vanino.* A nearly centinormal solution of iodine was prepared by diluting to a liter 100$^{cm^3}$ of nearly decinormal iodine in potassium iodide carefully standardized against exactly decinormal arsenious acid. A nearly centinormal solution of sodium thiosulphate (containing 1·7012 grm. of $Na_2S_2O_3$ to the liter) was made by diluting to a liter 100$^{cm^3}$ of a nearly decinormal solution of that reagent which had been standardized carefully against the standard iodine prepared as described. The solution of potassium iodide employed contained 10 grm. of that salt in the liter.

In conducting the experiments, a convenient amount of the solution of gold chloride was drawn from a burette, potassium iodide was introduced in the amounts indicated (always several times the theoretical equivalent of the gold, and more than enough to dissolve the aurous iodide precipitated at first), a sufficiency of clear starch indicator was added, the starch blue was bleached by the thiosulphate, and the iodine was added until the liquid assumed a faint rose color. Upon the theory that potassium iodide sets free two atoms of iodine for every

*Ber. d. d. chem. Gesellsch., xxxi, 1763.

molecule of auric chloride (or every atom of gold) present, and that the thiosulphate acts only upon the free iodine to form the tetrathionate in the usual manner, every cubic centimeter of the thiosulphate solution used in the reaction after deducting the amount equivalent to the iodine introduced to get the end-color, should represent

$$\frac{197{\cdot}3}{2(158{\cdot}22)} \times 0{\cdot}0017012 = 0{\cdot}001061 \text{ grm. of gold.}$$

TABLE I.

Gold chloride = 0·8710 to 1 liter.
Sodium thiosulphate, nearly $\frac{N}{100}$, = 1·7012 " "
Iodine nearly $\frac{N}{100}$, = 1·3697 " "
Volume at beginning of titration, approximately 50$^{cm^3}$.

	$AuCl_3$ taken. cm^3.	KI taken. grm.	$Na_2S_2O_3$ used. cm^3.	Gold found. grm.	Theory for gold. grm.	Error. grm.	Per cent.
(1)	5	0·05	4·02	0·00426	0·00435	−0·00009	2·1
(2)	"	"	4·01	0·00425	0·00435	−0·00010	2·3
(3)	"	"	4·06	0·00431	0·00435	−0·00004	0·9
(4)	"	"	4·07	0·00432	0·00435	−0·00003	0·7
(5)	"	"	4·04	0·00428	0·00435	−0·00007	1·6
(6)	10	0·08	8·17	0·00867	0·00871	−0·00004	0·5
(7)	"	"	8·15	0·00864	0·00871	−0·00007	0·8
(8)	"	"	8·16	0·00865	0·00871	−0·00006	0·7
(9)	"	"	8·15	0·00864	0·00871	−0·00007	0·8
(10)	"	"	8·19	0·00869	0·00871	−0·00002	0·2
(11)	"	"	8·46	0·00897	0·00871	+0·00026	3·0
(12)	"	"	8·24	0·00874	0·00871	+0·00003	0·3

Plainly, these results accord reasonably with the theory that two molecules of the thiosulphate are the equivalent in this reaction of two atoms of iodine and one atom of gold. There is no evidence whatever of the excessive action affirmed by Peterson.

The strength of the standard solutions used in the experiments described was such that an error of 0·01$^{cm^3}$ in reading the volumes used would correspond to an error of 0·00001 grm. of gold. It is not to be expected that such readings can be trusted ordinarily to a higher degree of accuracy than 0·02$^{cm^3}$. In case all three solutions should be read to this limit of accuracy with the errors of all lying in the same direction, the summation of error would correspond to 0·00006 grm. of gold.

In the following experiments, therefore, solutions obtained by properly diluting those of the previous series were employed. The use of a more dilute solution of gold obviated the neces-

sity for diluting the mixture of gold chloride and the iodide before titrating with the thiosulphate. It was found, however, that when the $\frac{N}{1000}$ solution of iodine is employed a correction of $0{\cdot}1^{cm^3}$ for volumes not exceeding 30^{cm^3} becomes necessary—the amount required to bring out the rose color in blank tests containing no gold. After the introduction of $0{\cdot}1^{cm^3}$ of $\frac{N}{1000}$ iodine into a mixture of potassium iodide and starch indicator of volume not exceeding 30^{cm^3}, a single drop of the gold solution—equivalent to 0·000002 grm. of gold—gave a distinct rose color: before such adjustment of the solution five drops—equivalent to 0·000010 grm. of gold—were needed to develop the same color.

TABLE II.

Gold chloride = 0·0871 to 1 liter.
Sodium thiosulphate, nearly $\frac{N}{100}$ = 1·7012 " "
Iodine, nearly $\frac{N}{100}$, = 1·3697 " "

Solution of gold chloride not diluted before mixing with potassium iodide.

A

	$AuCl_3$ taken. cm^3.	KI taken. grm.	$Na_2S_2O_3$ used. cm^3.	Gold taken. grm.	Gold found. grm.	Error. grm.
(1)	10	0·01	0·83	0·00087	0·00088	+0·00001
(2)	10	0·01	0·83	"	0·00088	+0·00001
(3)	10	0·01	0·80	"	0·00085	−0·00002
(4)	10	0·02	0·84	"	0·00089	+0·00002
(5)	10	0·02	0·88	"	0·00093	+0·00006
(6)	10	0·02	0·82	"	0·00087	0·00000
(7)	10	0·02	0·88	"	0·00093	+0·00006
(8)	10	0·02	0·83	"	0·00088	+0·00001
(9)	10	0·10	0·80	"	0·00085	−0·00002
(10)	10	0·10	0·82	"	0·00087	0·00000
(11)	10	0·01	0·83	"	0·00088	+0·00001
(12)	9	0·01	0·73	0·00078	0·00077	−0·00001
(13)	8	0·01	0·65	0·00070	0·00069	−0·00001
(14)	7	0·01	0·58	0·00061	0·00061	0·00000
(15)	6	0·008	0·51	0 00052	0·00054	+0·00002
(16)	5	0·008	0·41	0·00043	0·00044	+0·00001
(17)	4	0·005	0·35	0·00035	0·00037	+0·00002
(18)	3	0·005	0·24	0·00026	0·00026	0·00000
(19)	2	0·003	0·21	0·00017	0·00022	+0·00005
(20)	1	0·003	0·10	0·00009	0·00011	+0·00002

TABLE II (continued).

B

Gold chloride = 0·0871 to 1 liter.
Sodium thiosulphate, nearly $\frac{N}{1000}$ = 0·17012 " "
Iodine, nearly $\frac{N}{1000}$ = 0·13697

	$AuCl_3$ taken. cm^3.	KI taken. grm.	$Na_2S_2O_3$ used. cm^3.	Gold taken. grm.	Gold found. grm.	Error. grm.
(21)	10	0·01	8·39	0·000871	0·000890	+0·000019
(22)	9	0·01	7·45	0·000784	0·000790	+0·000006
(23)	8	0·01	6·30	0·000697	0·000668	−0·000029
(24)	7	0·008	5·50	0·000610	0·000583	−0·000027
(25)	6	0·008	5·12	0·000523	0·000543	+0·000020
(26)	5	0·005	4·23	0·000435	0·000449	+0·000014
(27)	4	0·005	3·38	0·000348	0·000358	+0·000010
(28)	3	0·003	2·55	0·000261	0·000270	+0·000009
(29)	2	0·003	1·71	0·000174	0·000181	+0·000007
(30)	1	0·003	0·90	0·000087	0·000095	+0·000008

These results run on the whole as regularly as could be expected, and the use of the dilute standard solutions is obviously of advantage.

In the practical application of any such process for the determination of gold, the elementary form of that metal is the natural starting point. To get the metal into solution with chlorine water or mixed hydrochloric and nitric acids is an easy matter, but the removal of the excess of the oxidizer by evaporation without reducing some auric chloride to the aurous form is difficult. We have found, however, that the free chlorine may be removed from a solution of auric chloride, without reducing the auric salt, by treatment of the solution with ammonia in excess, boiling gently, acidifying with hydrochloric acid and heating if necessary to redissolve the precipitate by ammonia, again treating with ammonia and heating, and once more acidifying. On the second addition of ammonia no precipitation usually takes place with the amounts of gold which we have thus handled, perhaps because enough ammonium chloride has been found to hold it up.

The following table contains determinations made with such a solution of pure gold leaf—tested gravimetrically as to purity.

Obviously, this method, which rests upon the hypothesis that sodium thiosulphate acts in the normal manner only upon the iodine set free by the interaction of gold chloride and potassium iodide, offers trustworthy means for the determination of small amounts of gold.

TABLE III.

Gold chloride made by dissolving 0·0104 grm. of pure gold in the manner described and diluting to 200$^{cm^3}$.

Sodium thiosulphate, nearly $\frac{N}{1000}$, = 0·17012 to 1 liter.

Iodine, nearly $\frac{N}{1000}$ = 0·13697 " "

Potassium iodide = 10 grms. " "

Portions were treated with the potassium iodide without previous dilution.

	$AuCl_3$ taken. cm^3	KI taken. grm.	$Na_2S_2O_3$ used. cm^3.	Gold taken. grm.	Gold found. grm.	Error. grm.
(1)	1	0·005	0·55	0·000052	0·000058	+0·000006
(2)	1	0·005	0·55	0·000052	0·000058	+0·000006
(3)	2	0·005	1·06	0·000104	0·000112	+0·000008
(4)	2	0·005	1·08	0·000104	0·000114	+0·000010
(5)	5	0·01	2·45	0·000260	0·000260	0·000000
(6)	5	0·01	2·50	0·000260	0·000265	+0·000005
(7)	5	0·01	2·45	0·000260	0·000260	0·000000
(8)	5	0·01	2·50	0·000260	0·000265	+0·000005
(9)	5	0·01	2·50	0·000260	0·000265	+0·000005
(10)	10	0 02	4·86	0·000520	0·000515	−0·000005
(11)	10	0·02	4·85	0·000520	0·000517	−0·000003
(12)	10	0·02	4·90	0·000520	0·000520	0·000000
(13)	10	0·02	4·80	0·000520	0·000512	−0·000008
(14)	10	0·02	4·84	0·000520	0·000516	−0·000004

ART. XXX.—*The Mineralogical Structure and Chemical Composition of the Trap of Rocky Hill, N. J.;* by ALEXANDER HAMILTON PHILLIPS, D.Sc.

Introduction.

THE Mesozoic trap rocks, or trap dikes of the eastern coast of the United States, are almost entirely confined to a comparatively narrow strip of country, in which the Triassic formation appears at the surface. The two seem to be so constantly connected, that almost every isolated Triassic area, however small, is accompanied with its corresponding intrusions of trap.

The Triassic strata of the Atlantic coast extend in a northeast and southwest direction from Nova Scotia to North Carolina, through an interrupted course, and are found more or less in isolated patches along the western portion of the coastal-plain, and lying next the older crystalline schists of the Appalachian range, into and through the border of which the trap dikes also extend.

In size, these dikes vary from a foot or so in thickness to such large masses as are represented by the Palisades of the Hudson. Their direction, especially of the larger masses, conforms in a marked degree to the strike of the strata in which they lie, and owing to their greater power of resisting erosion, they appear on the surface as parallel ridges, which mark the transition from the low level country of the coastal-plain to the higher foot-hills of the Appalachian Range.

Throughout this entire area of some twelve hundred miles in extent, the mineralogical composition of the trap is wonderfully alike, as has been pointed out from results of analyses of this rock from localities widely separated.[1] *

The specific gravity of these traps varies, from data collected by J. D. Dana,[2] from 2·94, that of the Palisades, to 3·16, that of a specimen from North Carolina; while there are cases in which the specific gravity falls as low as 2·83.[3] 3·16 still seems to be the maximum.

The mineralogical constituents were generally supposed to be magnetite, augite and labradorite. G. W. Hawes[4] was the first to show the complex character of the feldspars, from analyses made of specimens of the West Rock, at New Haven, and of the New Jersey Palisades. Campbell and Brown later pointed out other complexities than that of the feldspars, and a specimen from Milford, N. J., is described as a hypersthene-diabase[5]; as well as an olivine-diabase from Virginia.

* See references given on p. 285.

Magnetite, augite and labradorite may be considered as the most widely distributed and characteristic minerals of the Triassic traps, and, from the constant occurrence of small percentages of P_2O_5 in all analyses, apatite might be added to these three. The above is, however, by no means a complete list of primary minerals which occur locally, for added to these, olivine, anorthite, hypersthene, biotite, pyrite, and zircon are local minerals, given here in the order of their frequency.

The minerals of contact and decomposition, or of secondary formation, are well known and have a well deserved reputation from their beauty and perfection of crystalline form; they have found their way into all collections.

Description of the Rocky Hill Dike, and its relation to the Sedimentary Strata.

In its relation to the sedimentary strata, the Rocky Hil. dike is no exception to the rule, lying well up in the strata, which represent the Triassic beds, and especially so at either of its extremities.

The Triassic has been divided here into three divisions[6]: the Stockton, Lockatong and Brunswick shales; the Stockton being the lower and older in the series, lying just above the crystalline gneiss.

The Rocky Hill trap extends for some fifteen miles in a northeast and southwest direction through these beds of shale, lying for the most part within the Brunswick shales, to the strike of which it seems to conform for about six miles west of the village of Rocky Hill, where it makes a slight curve, and breaks through the strata extending to a higher horizon in the Brunswick shales; at this bend the ridge reaches its highest elevation, Mount Rose possessing an elevation of 415 feet, as given in the New Jersey Geological Report. From this point it gradually declines in height eastward, until the ridge entirely disappears at the country level east of the Pennsylvania railroad. One mile east of Rocky Hill village it divides into two branches; one extends east, the other north towards Griggstown, this branch being much the smaller of the two in extent, and separated from the easterly one by a formation known as the Sand Hills. Whether these two branches are connected by a sheet of trap underlying the Sand Hills as suggested by N. H. Darton,[7] produced by an upward folding of the trap is difficult to prove, although from consideration of the whole lay of the strata, this seems very probable.

The surface occupied by the trap is thickly strewn with large irregular, though somewhat rounded masses of rock in

different stages of decomposition. The resistance offered by the basic traps of this formation to atmospheric weathering is very marked, in contrast to acid dikes; the acid dikes weathering much faster than the enclosing sedimentary rocks,[8] leaving long channels, while the basic traps are prominent as ridges. The soil lying between the surface boulders and derived from them by decomposition is never very deep. In quarries, that portion lying at the surface has a reddish appearance, caused by the oxidization principally of the ferrous iron contained in the augite. This surface weathering does not extend to depths much greater than ten feet, in the rock mass itself; individual crystals in macroscopic specimens from depths greater than this seem perfectly fresh. The disintegration reaches much greater depths along joints and cracks. In the quarry at the Hopewell end of the dike an entirely different decomposition has taken place, much of the rock mass here exposed is soft and chloritic in nature, and has taken up 3 per cent of water; some specimens show even more than this, and well crystallized calcite and zeolites appear in the cracks and joints.

In width the Rocky Hill dike does not vary much from a half mile. Along the Mount Rose road, which crosses it at a right angle, it measures 860 feet. Along the gorge of the Millstone River, which also cuts through it at Rocky Hill village at nearly a right angle, it measures 4000 feet, and if we take into consideration the dip of the enclosing strata, to which it seems to conform at these points, its thickness measured at right angles to the dip at Mount Rose would be 250 feet, at the Millstone 1200 feet. That the dip of the enclosing strata is conformed to, at least in the middle section of the dike, is proven, in lack of evidence shown by direct contact, by the baked condition of the shales lying on the north or upper side, in contrast to those lying on the south or under side. The shales lying on the north from near Griggstown to Mount Rose having been brought in close contact with the liquid magma, have been semifused and upon cooling crystallized in some cases, but generally developing spilosites in large quantities. In particularly favorable localities, such as north of the canal bridge at Rocky Hill, the dark green crypto-crystalline nodules reach their largest size, being in some cases three-quarters of an inch in diameter. These nodules do not appear to exist at all on the south side of the dike, and the explanation seems to be, that the shales resting directly upon the molten mass have suffered far greater baking than those underneath, for if the dike were vertical we should expect an equal baking on both sides, which, indeed, is the case west of Mount Rose, where the trap dike no longer conforms to the strike of the

shales, but breaks up through them, its surface area becoming very much narrowed in consequence.

At several points in the fused shales well crystallized epidote and tourmaline have been found, and especially at the Griggstown copper mine, where very perfect crystals of black tourmaline completely fill some specimens of the shale. They are hemimorphic, showing the hexagonal prism with fine longitudinal striations, terminated at one end by the rhombohedra $(02\bar{2}1)$ and $(10\bar{1}1)$, the antilogous pole being more complicated. Here also amygdaloid cavities were found, one of which was 1·3 inches in length, with walls thickly studded with well-formed crystals of epidote, calcite and a yellow mica, probably chalcodite.

Macroscopic Description.

At the village of Rocky Hill, the Millstone River cuts through the trap ridge at nearly a right angle, forming a gorge 150 feet deep; along the eastern side of this gorge the Rocky Hill Stone Storage Company has opened three quarries, located in different positions of the dike, as related to a vertical cross-section. No. 1 is near the lower side, 480 feet from the contact border; No. 2 is near the middle of the dike, 1350 feet from No. 1, and No. 3 420 feet from the upper contact and 1600 feet from No. 2. These distances are only approximate, as the upper and lower contacts cannot be made out definitely. Quarry No. 2 is the only one worked at present, rock being taken out and crushed for road and ballasting purposes. Each of these three quarries represents a different phase of the rock, not only in macroscopical appearance, but also in the chemical composition of the mineral constituents, as well as in the analyses of the rock as a whole.

Specimens near the contact with the shale have a very fine, granular, almost massive structure, appearing to the eye homogeneous, except here and there, where light is reflected from an almost microscopical cleavage face of a feldspar crystal; otherwise the boundary rock, and especially on the lower side, is a dark, slate-blue color, massive and compact, showing no cavities or schistose structure. Passing in from the cryptocrystalline border region, when quarry No. 1 is reached, the rock has assumed the characteristic texture of an ordinary dolerite; here it presents a coarse-granular appearance, in which its two prominent minerals, feldspar and augite, are easily distinguished; as the aggregation of feldspar crystals proceeds, the color of the rock is less dark, and specimens from quarry No. 2 appear much lighter than any others. Here the augite crystals reach a length of $\frac{3}{8}$ of an inch. In this region there is a well-defined schistosity developed, produced by the

parallelism of the long axis of the augite crystals. The excellent cleavage of these crystals gives a decidedly easy fracture along this direction, to the entire rock mass. This easy fracture is taken advantage of by the workmen in splitting out blocks for street paving.

There can be distinguished in the coarse variety, dark, irregular, highly lustrous though small aggregates of magnetic oxide of iron. The size of these aggregates increases with the coarseness of the specimen.

Scattered throughout the entire mass are very minute crystals of chalcopyrite, too scattered to form a factor in the analyses of the rock. In some rare localities they have been segregated into masses, as much as half an inch in diameter. It may be mentioned here that copper minerals are found at several localities along the contact of the trap and the shale, especially at Griggstown, where a small quantity of ore has been taken out in the form of silicate and carbonates.

The structure found in quarry No. 2 represents the conditions which are found throughout the greater portion of the dike, from the Millstone River westward. Eastward the coarseness decreases, due undoubtedly to the fact that erosion has not exposed the deeper, more central and coarser portions. Quarry No. 3 represents the maximum coarseness and differentiation of the rock's components, for here, as is afterwards shown from the analyses, the composition is the farthest removed from the original magma, as represented by the composition of the microcrystalline band along the contact. The aspect of the rock has changed, due to two primary causes. In the first place, this is due to the elongation of the diallage-like augite crystals, measuring often an inch, and occasionally two inches in length. With its excellent cleavage and metallic schiller, it forms a very striking feature, while the schistose arrangement marked in quarry No. 2 has been lost here, probably the pressure to which it was due having been removed or relieved by smaller secondary dikes, though a diligent search of the locality has failed to reveal them. There are some small dikes northeast of the Rocky Hill trap, though their connection with it is not apparent. Judging from the perfection of the crystals of diallagic augite, there could at the best have been no very great disturbance, as they have suffered but slight distortion, their long axis being but slightly curved, and showing no displacements.

In the second place, the color of the feldspar has changed from white to a very light flesh color, which certainly indicates a change in its nature, which is also brought out in the analyses. That portion of the dike which presents these characteristics is limited to a small area, and nowhere outside of quarry

No. 3, or its immediate vicinity, are crystals of like perfection and size found. It is also remarkably near the upper contact border, and judging from its differentiation, coarseness and crystalline perfection as compared with other portions of the dike, it must have been subjected to slower cooling, and has been the last portion to consolidate, or might have been in close contact with the source from which the molten magma was forced out, and consequently nearer the source of heat. This would explain the slower cooling, but not the difference in composition, which specimens from these three localities show.

The shales just above this point show an extensive baking, for it is here that the spherulites reach their maximum, both in number and size, indicating that they have been subjected to a more intense heat, or one of longer duration.

Microscopical Description.

Microscopically, the groundmass shows the absence of glass, and is therefore holocrystalline. In the finest grained portions the feldspars are present in the characteristic lath-shaped crystals, metasilicates lying between them, in the form of fine crystalline aggregates of grains or wedged-shaped anhedrons, each having a different crystallographic orientation.

This structure, with the absence of glass, following the classification of Iddings[9] for these rocks, is that of a dolerite or diabase, in contrast to the basalts, in which glass is present in the groundmass.

Magnetite, being one of the primary minerals, and characteristic of these diabases, is found liberally represented in sections from all portions of the dike; and in those from the contact-band, subject to more rapid cooling and crystallization, magnetite is evenly distributed as fine irregular grains, showing no crystalline boundaries, except in a few cases where octahedral outlines appear. Since the magnetite is not found as inclusions in the feldspars, but is contained in everything else except in the apatite, the formation of the mineral in the magma has been subsequent to that of the feldspars. The conditions favorable for its separation have been of considerable duration, as the relative quantity contained in the dike has increased in sections from coarser specimens, as from quarry No. 3; here the masses of magnetite have reached such a size as to form a macroscopic feature of the rock. Some of these larger masses completely enclose feldspar crystals as well as apatite, which appears in hexagonal sections in an otherwise completely dark field of magnetite.

Qualitatively all the magnetite gives very strong reactions for titanium, and judging from this it must carry nearly if not

all the one per cent. or more of the titanic oxide found in the rocks.

While magnetite is one of the first minerals to separate from a magma on cooling, the relation of the magnetite to the other minerals in the sections, enclosing feldspars, apatite, and even augite, being wedged in between other crystals in the sections, would indicate that its separation has been a slow, continuous one, and since its relative quantity increases in that portion of the dike which we believe has been the last to consolidate, there have been changes in the magma favorable to this increase. From these facts we would conclude that the magma, after having been intruded between the sedimentary strata, was subjected to a very slow and gradual cooling, and possibly under high pressure, which would also tend to keep the magnetite in solution. That this cooling was slow, and that after injection the magma was subjected to little or no subsequent disturbance, is also brought out by the condition of the apatite crystals, which are everywhere present. In sections from the outer portions, apatite is represented by numerous slender but short needles, which increase in size until in sections from quarry No. 3 they reach a diameter of ·2^{mm} and a length of 1·5^{mm} before disappearing out of the section, being uninterrupted throughout their long axis and extending through adjacent minerals, both magnetite and feldspars. As these are the first crystals to form, any slight disturbance during the slow cooling would have been sufficient to break up this continuity.

Olivine.—The conditions favoring the separation of olivine in the Rocky Hill diabase have been very limited, as crystals of it are very few in number and confined to the border area, but these few present interesting facts when their method of decomposition is considered. They occur as rounded grains for the most part, but few showing an ill-defined crystalline form. The larger crystals, where fresh, are of a light green color, and show a good cleavage as well as irregular fracturing.

In their decomposition they have followed two distinct methods. The first, or earlier one, is by the formation of grains of magnetite, appearing as black granular strings, following all the cleavage cracks and irregular fractures of the crystals; and especially on the border, the black grains have been produced to such an extent as to surround each crystal with a decidedly dark band, and in the case of some of the smaller nodules, this secondary formation of iron oxides has proceeded so far, that the entire body of the crystal is nearly opaque, and might be mistaken for a mere collection of magnetite granules. This method of decomposition of olivine is described by Zirkel[10] in connection with the olivine of gabbros, and furthermore he states that it is never found in connection

with the olivine of basalts. Prof. J. W. Judd,[11] in connection with the older peridotites of Scotland, concludes that it is a phenomenon which takes place only at a great depth from the surface, and consequently at considerable pressure. From this we may conclude that originally this trap was buried far below the surface at the time of its intrusion, and has since been elevated to its present position, and the strata originally covering it have been carried away.

The second method of the olivine decomposition is that generally found at the surface, in which an olivine rich in iron, such as this seems to be, by oxidation and formation of small scales of limonite and hematite, becomes dark yellow, brown or red. The greater number, and especially the smaller rounded grains, have become deeply colored by this formation of iron oxide, while the larger, some at least, are still perfectly fresh, with the exception of the magnetite grains. Their rounded shape is due to a partial resolution in the magma, as is shown by the corrosive cavities.[12] There are present, also, large inclusions of glass, so characteristic of olivine. The absence of serpentine as a decomposition product would also point to an olivine with large percentage of iron.

In size the olivines attain a maximum diameter of about .04^{mm}.

Augite.—The crystallization of the diallage-like augite is varied. In slides of the finer or diabase structure, the groundmass is composed of a collection of microscopical crystals, with now and then a lath-shaped section of a larger augite lying among them. In sections at right angles to the *c*-axis the characteristic prismatic cleavage is well developed, as is also the cleavage parallel to the orthopinacoid; crystals from quarry No. 1 show a maximum extinction angle of 46°.

These diallagic crystals constantly increase in length as we pass in from the border; in quarry No. 2 they are 8 to 10^{mm} in length; in quarry No. 3 they reach their maximum length. They are all elongated in the direction of the *c*-axis, and the pinacoids are developed at the expense of the prism faces, giving them a flattened appearance. The color constantly deepens, and in reflected light they appear about black, except on cleavage faces where a characteristic schiller is developed. The cleavage faces parallel to the prism show the trace of a twinning plane parallel to the orthopinacoid, running directly through the middle of the crystals, each twin being equally developed. This twinning is very constant in the larger crystals, and between crossed nicols, in some instances, polysynthetic twinning is indicated along this line. In transmitted light, their color is uniformly brown, with little pleochroism. Extinction is undulatory, indicating a shell-like structure, the angle of extinction being greater for external than

for the internal layers. This angle constantly increases from the fine-grained crystals, where it is 46°, reaching a maximum of 58° in the larger crystals of quarry No. 3. Sections parallel to the vertical axis show a constant structure of fine striations; traces of interposition planes, parallel to the basal pinacoid. These striations appear on all sections which are parallel to the vertical axis, as running across, between the cleavage cracks. They do not appear on sections parallel to the base, neither as lines or dots, which would indicate that they are not fibres, but owe their origin to polysynthetic twinning parallel to the basal pinacoid. Their trace, on sections parallel to $\infty P \breve{\infty}$, makes an angle of about 74° with the trace of the composition face of the twins twinned parallel to $\infty P \bar{\infty}$, when the lines are symmetrical on either side. This would prove these lines to be traces of planes parallel to 0P, as the angle β for monocline pyroxene is 74° 10′; these very fine interposition planes play an important part in the decomposition of the mineral, as well as in the production of the peculiar schiller. The great number of small inclusions contained in the crystals are symmetrical in regard to the axis, and fall into two groups; those parallel to the vertical axes, and those arranged along the twinning planes, parallel to 0P. The inclusions are of the nature of cavities filled with hydrated oxides, formed by solution of the crystal body under pressure, as described by Judd, who infers that they are negative crystals, and mark the line of least resistance to solution, and therefore stand in the same relation to the body of the crystal as the etching figures do to the surface or faces. Of the two systems that one in which the long axis is parallel to the $\dot{c}$-axis of the crystal offers the greater resistance to solution, and requires a higher pressure, consequently takes place at greater depths.

This system is the better represented of the two and is very characteristic of sections from the central and upper portions of the dike; they are considerably elongated, and occur in large numbers. If they are secondary formations it would add another proof, that this dike was formed at a considerable depth below the surface. Whether they are secondary formations is very difficult to determine. The matrix surrounding them has not been bleached as if the oxides of iron filling them had been drawn from their immediate vicinity. This is in decided contrast to other granular inclusions, evidently secondary products, found as a result of surface action, in which the body of the crystal presents a decided bleaching.

The formation of these secondary granules begins first at the margin and works its way toward the central portions of the crystal, following cleavage cracks and fractures, and especially along interposition planes running across between the cleavage

cracks; following this system, they form parallel lines of fine granules of magnetite, limonite, etc., which seem to be also an important factor in producing the schiller-like luster, and they would evidently be a result of surface action. These secondary granules are very numerous since the percentage of ferrous iron in all these crystals is very high.

As decomposition advances, other products are formed and become mixed with the oxide of iron granules, such as fibrous chlorite, biotite and epidote; even when this has reached such an advanced stage that the original crystal is replaced by a crystalline aggregate, the position of the fine interposition planes of the mother crystal is still marked by lines of dark granules. The oxidation of the large amount of iron contained in the diallage is the first step in the rock's decomposition and has commenced even before the clouding of the feldspars.

Biotite, as a primary mineral, is absent, and is found only as a secondary product derived from the decomposition of the diallage. It is present only in those slides which show the diallage in an advanced stage of decomposition; its formation begins after a considerable amount of the iron has been oxidized.

Quartz.—What has been said of biotite may also be said of quartz, to a great extent, with this exception, that in specimens from quarry No. 3 there are a small number of quartz grains which are evidently primary, judging from their size and the freshness of the surrounding crystals. Secondary quartz is formed in connection with the formation of chlorite in the decomposition of the diallage; this is best represented in the Hopewell quarries, where quartz granules can be picked out of the mass of chlorite.

Amphibole, in the form of hornblende, is represented in a few slides from the central portions of the dike, but is most frequent in all slides from quarry No. 3 and here stands in a very intimate relation and is closely connected with the history of the diallage, from which it has been derived by paramorphism. It occurs in two distinct varieties: one compact, yellow-brown in transmitted light, the other fibrous and light-green, both of which are very pleochroic. In the green variety, the ray vibrating parallel to c is decidedly bluish green; that parallel to a and b yellow. In the compact form, the pleochroism is shown only in shades of brown and yellow; the absorption is very marked, especially in the compact variety, and sections with the light rays vibrating parallel to c are very dark. The absorption in both varieties is as usual $c > b > a$. The prismatic cleavage is perfectly developed and is strikingly in contrast to that of the neighboring diallage crystals. The maximum extinction-angle measured from cleavage cracks in

the prism zone was 16°. The compact as well as the fibrous form exists as boundaries to the diallage[13] with their long axes parallel. The fibres are limited to the outer portions of the diallage, while the compact is distributed as patches in the interior of some of the diallage crystals, as well. These interior patches would point rather to paramorphism than to decomposition as the agent to which the hornblende owes its origin. Neither variety would be considered as a primary component.

Feldspars.—In all slides from quarry No. 1 and the border region, the structure of the feldspars is eminently that which is so characteristic of the diabases, being ophitic in contrast to the irregular appearance of feldspar crystals marking the gabbro structure. Both of these structures are perfectly represented in different portions of the dike.

In sections of the finest grained specimens, which appear macroscopically to be almost homogeneous, the feldspars are always well formed, and are always present in lath-shaped sections; their average size is ·21^{mm} in length and ·046^{mm} in width, which will also give a good idea of the fineness of this diabase. Toward the center of the dike, the feldspar crystals constantly increase in size, and by the time quarry No. 1 is reached they have increased to ·5^{mm} in length and ·15^{mm} in width, still presenting very strongly the ophitic structure; in numerous cases, however, there is a strong tendency toward the granular, irregular, or gabbro structure. This is brought about by a shortening of the *a*-axis, parallel to which the lath-shaped crystals are elongated.

Twinning after the albite law is common, and generally the smaller crystals are composed of a single pair of twins. As the crystals increase in size, polysynthetic twinning after the albite law is the rule. The large angles of extinction on sections perpendicular to 010, rising to a maximum of 37°, coupled with the double refraction, would indicate a feldspar rich in calcium or one in which the ratio of anorthite to albite was high or of the composition of bytownite. The feldspars of quarry No. 2 upon the whole have a higher index of refraction, and the difference in the interference colors is very marked. The twinning is more extensive and many of the crystals show a decided compound nature. This is brought out by the lamellæ in the central portion of the compound crystals extinguishing at larger angles than the exterior bands, also by the interference colors of the different lamellæ. The central lamellæ are also much narrower, and the lath-shaped form is giving way to granular and irregular-shaped crystals in sections.

In the identification of the feldspars, samples of the powder separated with the Thoulet solution were used, and the angles

of extinction on the base in connection with the albite twinning striations or the prismatic cleavage were measured. In the sample with a gravity greater than 2·69, fragments showing the lath-shaped crystals with narrow striations clearly predominated over the fragments of the granular form of crystal with wide twinning laminations. The reverse of this was found to be the case in the sample separated with a gravity less than 2·69.

The compound nature of these five samples is indicated by the difference in the extinction-angles of the several laminæ of which they are composed, so that the separation of feldspars of complex nature is at the best only a coarse assorting, in which the majority of particles will have a composition agreeing with the specific gravity, or will be homogeneous. The fineness to which each particle would have to be reduced to separate these interlaminated feldspars, is far beyond the practicability of separating them with the solution, owing to the slowness with which they settle. The angle of extinction measured on the base was found to vary from $-27°$ to $-4°$; the lamellæ giving the larger angle were found to be the very narrow, more centrally located. These angles indicate that the analysis of this sample would lie between the composition of Ab_1An_8 on the one side and Ab_1An_1 on the other.[22]

In the sample separated with a gravity less than 2·69, the fragments with the very narrow lamellæ had disappeared. The angle of extinction was found in numerous cases to be almost parallel with the twinning striations, showing that the proportion of anorthite had decreased until the composition is possibly that of oligoclase or andesine. In quarry No. 3 the crystallization of the feldspars is very irregular, and complicated by an increase in the tendency to form, in addition to the twinning after the albite law, numerous twins after the Carlsbad law, showing both straight and irregular contact planes. Numerous patches exhibit the cross hatching produced by the combination of the albite and pericline twinning. The Baveno type is also present in frequent cases. The large masses of feldspar do not give distinct crystalline outlines, being moulded by the surrounding diallage crystals and magnetite, fragments of which they enclose. Their crystallization must have been either at the same time or after that of the diallage. These masses of feldspar preserve the same crystallographic orientation throughout, thus presenting the poikilitic structure common in gabbros.[23]

A large proportion of the feldspars of this locality have become clouded and stained dark by the infiltration of iron from neighboring decomposing diallage; the cloudiness being produced by the first steps in kaolinization.

Chemical Analysis.

In the analysis of the rock, what seemed to be typical specimens from quarries No. 3 and No. 2, and a specimen from the microcrystalline contact region, were selected. These three specimens, it was thought, would represent the three stages in the trap so decidedly different in the development of its crystals, and would also give a good basis, by means of which the magmas from out of which they were crystallized might be compared. The specimen from the border was taken, as the magma must have consolidated upon contact with the sedimentary rock, or at least soon after injection between the strata, and can therefore be held to represent the composition of the entire mass at the time of its intrusion, or its original composition.

In specific gravity these specimens fall in the middle of the series observed in the Mesozoic trap. The average for the entire dike would be about 3. The densities of specimens collected at various localities along the ridge vary between 3·125, the density of a specimen from the Hopewell extremity, and 2·935, the density of one taken near the village of Rocky Hill. The density of the typical rock from quarry No. 2 was found to be 2·968; that of quarry No. 3, 3·023. These variations in density are no more than would be expected, caused by the local change, both in the composition and relative proportion of its primary minerals.

Analyses of the Rocky Hill Trap.

	I. Quarry No. 3.	II. Quarry No. 2.	III. Contact band.	IV.	V.	VI.
SiO_2	56·78	50·34	51·46	52·1	52·53	52·37
TiO_2	1·44	1·56	1·06	----	·32	·21
Al_2O_3	14·33	15·23	13·98	16·7	14·35	15·06
Fe_2O_3	5·76	2·82	2·66	----	5·93	2·34
FeO	9·27	11·17	8·92	12·7	5·45	9·82
MnO	·25	·14	----	----	trace	·32
CaO	5·26	9 61	10·49	10·8	10·27	7·33
MgO	1·58	5·81	7·59	3·2	7·99	5·38
Na_2O	3·43	2·93	4·75	2·3	1·87	4·04
K_2O	1·75	1·02		·8	·97	·92
P_2O_5	·36	·20	·17		·15	
					SO_3= .08	
H_2O above 110°	·10	·07	*	1·4 ignition	1·23	2·24
H_2O below 110°	·33	·19	----	----	----	----
	100·64	101·09	101·08	100·	101·14	100·03

* Unfortunately for direct comparison this specimen was dried at 150° before it was analyzed, but the percentage of H_2O must have been small.

Analyses IV to VI of Mesozoic trap are given for comparison; IV is an analysis of Rocky Hill trap, by G. H. Cook; V, by F. A. Genth, from York Co., Pa.; VI, Trap rock at Meriden, Conn., by J. H. Pratt.[15]

Analyses V and VI represent the average composition of the Mesozoic trap of the Atlantic coast, and by a comparison with these analyses, the variation of the Rocky Hill trap from the mean will be apparent. The most important points to be noted are: first, that the Rocky Hill trap is high in alkalis and especially so in potassium, which also becomes concentrated locally in quarry No. 3. This high percentage of alkali is a factor which exercises an important influence in the composition and formation of the various feldspars.

Second, the percentage of iron is high, especially the ferrous iron. The iron as well shows a decided concentration in No. 3. This high amount of ferrous iron produces a diallage remarkably high in FeO, as the analyses will show. While the TiO_2 is very high in comparison with the two analyses given, there are other analyses in which TiO_2 is present in equally as high percentages. In the West Rock, New Haven, there is 1·41 per cent of TiO_2.[16]

In the separation of the various mineral components for analysis, the magnetite was taken out with a small electromagnet, the strength of which was not sufficient to attract the diallage; though diallage in which magnetic granules had developed as a result of decomposition and oxidization of the ferrous iron was removed. After the magnetic portions were removed, the remainder was separated with the Thoulet solution. The diallagic augite separated at the highest specific gravity of the solution; after this trials were made at various stages of dilution, until the specific gravity of the feldspars was reached. Up to this point very little material could be separated, and this, when examined with the microscope, was found not to be homogeneous.

Neither in specimens from No. 2, or from No. 3, was the amount separated above the specific gravity of 2·72, that is after magnetite and diallage had been removed, very large. In the further separation of the feldspars, the solution was diluted to a specific gravity of 2·69, the theoretical density which would separate the two species of feldspars, labradorite on the one side, and andesine on the other[17]; then again diluted to a density of 2·60, separating the anorthoclase from albite. In order to obtain as pure sample as possible of each, for analysis, each specimen was put through the solution several times. While the specific gravities of the feldspars overlap each other to a great extent, still these portions separated will give an idea of their molecular variation in different positions

of the dike, i. e. at different steps in the crystallization of the magma.

In the analysis of the diallage-like augite the sample used in No. 2 was separated at the highest specific gravity of the solution. That used in No. 3 was selected by hand, as the crystals were quite large.

Analyses of Diallagic Augite.

	No. 2.	Ratio.	No. 3.	Ratio.	IV.*
SiO_2	47·72	·795	48·54	·809	50·71
Al_2O_3	3·44	·014	5·50	·053	3·55 (MnO)
Fe_2O_3	5·93	·037	2·77	·017	·81
FeO	18·34	·254	21·25	·295	15·30
CaO	11·40	·205	10·97	·196	13·35
MgO	12·89	·320	7·67	·191	13·63
Na_2O	·86	·013	3·10	·039	1·48
K_2O	·37	·003			
Ignition	·00	----	·82	----	1·17
	100·95		100·62		100·00

No. 2. R_2O : RO : R_2O_3 : SiO_2
·016 : 779 : ·051 : 795

No. 3. R_2O : RO : R_2O_3 : SiO_2
·039 : 682 : ·07 : 809

From the chemical composition these two pyroxenes lie between the molecule of hedenbergite ($CaFeSi_2O_6$) on the one side and diopside ($CaMgSi_2O_6$) on the other, of which they are isomorphous mixtures[18]; combined with these is a small proportion of the alkali-bearing pyroxene ($NaFeSi_2O_6$). The magnesia-bearing molecule separates out first at higher temperatures, decreasing the percentage of Mg in the rock as a whole; this has been carried to such an extent, that when No. 3 is reached, this locality being the last to consolidate, the percentage of MgO has been reduced to 1·58. The magnesia content has been a decreasing factor from the beginning of crystallization; decreasing from 7·59 per cent in the contact, to 1·58 per cent in No. 3. As the pyroxene is the only magnesia-bearing mineral present, with the exception of olivine in the contact region, the greater portion of this change in per cent of magnesia present is caused by the variation in the pyroxene molecule. The change in the iron-bearing molecule is not so clear, it being obscured by the magnetic oxides, which increase along the same direction as the ferrous component of the pyroxene; what has been lost by the lack of magnesia in

* Augite from West Rock, New Haven, Proc. U. S. National Museum, vol. iv, p. 132.

the magma has been made up in ferrous iron and alkalis. The tendency is, then, to form pyroxene at the border, rich in magnesia, of the composition of $CaMgSi_2O_6$ when the magma is rich in magnesia, or of the composition of $CaFeSi_2O_6$ when the magma is rich in iron.

The calcium in the pyroxene does not seem subject to much change.

There has been an increase in the alkali-bearing molecule, acmite, as the amount of SiO_2 has increased. This increase of the acmite molecule as the acidity of the magma increases, is in accord with the experiments of F. Becke.[19] He points out that the acmite molecule takes part in the composition of monoclinic pyroxene, crystallizing from magmas with a percentage of SiO_2 of 50 or above. With the increase of 6 per cent of SiO_2 from No. 2 to No. 3 there is a decided increase of K_2O and Na_2O found in the pyroxene. Campbell and Brown[5] have shown that in this Mesozoic diabase rich in MgO, where it reaches an amount equal to 12 per cent or more, the orthorhombic pyroxene appears as the mineral hypersthene. We would not expect an orthorhombic pyroxene to appear in the Rocky Hill diabase, as the proportion of (FeO+MgO):CaO in the analysis showing the highest percentages of these, is as 1·7:1, a proportion of FeO and MgO far below the ratio at which it has been found necessary for these to be present, in order that they, in crystallizing, should form an orthorhombic pyroxene. The molecular relation of (MgO+FeO):CaO must be as 3:1 or greater.[20] This high proportion of MgO+FeO is only locally reached in this diabase, and for that reason it is to be expected that the metasilicate is almost invariably some form of the monoclinic pyroxene.

Analyses of Feldspars from Quarry No. 2.

	I.		II.		III. West Rock, N. H.[4]		IV.	V.
	Gravity greater than 2·69.		Gravity < 2·69.		Gravity > 2·69.	Gravity < 2·69.	Gravity 2·703.	Gravity 2·659.
SiO_2	53·84	·899	62·26	1·037	52·84	60·54	53·7	62·
Al_2O_3	29·30	·287	21·87	·216	28·62	24·11	29·6	24·
Fe_2O_3	·81	·005	·54	·003	1·52	1·14	----	----
CaO	10·08	·180	6·53	·116	11·81	9·15	11·8	5·3
MgO	·28	·007	·15	·003	·46	·27	----	----
Na_2O	5·31	·085	7·98	·128	2·38	4·11	4·9	8·7
K_2O	1·16	·012	1·20	·012	·86	1·06	----	----
Ignition	·44	---	·32	----	1·06	·59	----	----
	101·22		100·85		99·75	100·97		

I. Gravity > 2·69. Ratio of

$$R_2O : RO : R_2O_3 : SiO_2 = ·097 : 187 : ·292 : ·899.$$

In this feldspar the albite molecule is to the anorthite molecule as 1 : 1+ or the feldspar is a normal labradorite, which agrees well with the optical properties as found in quarry No. 2.

IV gives the theoretical percentage composition of a labradorite of the proportion of 3 molecules of albite to 4 molecules of anorthite[21].

II. Gravity < 2·69. Ratio of

$$R_2O : RO : R_2O_3 : SiO_2 = \cdot140 : 119 : 219 : 1\cdot037.$$

This would represent a feldspar of the composition of albite to anorthite in the proportion of 5 : 2+ and would be that of an oligoclase.

V represents the composition and gravity of an oligoclase of the proportion of 3Ab : 1An.[21]

Feldspars from Quarry No. 3.

	I. Gravity > 2·69.	Ratio.	II. Gravity < 2·69.	Ratio.	III. Gravity < 2·60.	Ratio.	IV. Gravity 2·577.
SiO_2	66·84	1·110	71·68	1·195	66·28	1·104	66·79
Al_2O_3	17·98	·176	15·02	·147	16·79	·164	19·36
Fe_2O_3	2·60	·016	2·48	·015	1·60	·010	·91
CaO	4·02	·071	3·86	·068	·71	·012	·80
MgO	·48	·012	·12	·003	·13	·003	·13
Na_2O	5·46	·088	5.52	·076	9·76	·057	7·34
K_2O	1·72	·018	1·37	·014	5·31	·056	4·95
Ignition	·72		·00		·49		
	99·82		100·05		101·07		100·28

I. $R_2O : RO : R_2O_3 : SiO_2$ = 106 : 83 : 192 : 1·110 } = 9 Ab : 3·5 An.

II. $R_2O : RO : R_2O_3 : SiO_2$ = 90 : ·71 : 162 : 1195 } = 5 Ab : 2 An.

III. $R_2O : RO : R_2O_5 : SiO_2$ = 213 : 15 : 174 : 1104 } = 6 O_1 : 22 Ab : 1 An.

$K_2O : Na_2O$ = 56 : 157

IV is the composition of an anorthoclase.[24] In the analyses of the feldspars from quarry No. 3 it was impossible to get good samples, from the fact that they are considerably decomposed and stained by infiltration of iron; in addition to this all the quartz found in this locality will be included in II, and for that reason the percentage of SiO_2 here runs up to 71. While the above analyses cannot strictly be taken to represent the composition of pure feldspars, they will represent, however, the relation of K_2O, Na_2O and CaO in the feldspars of this position in the dike, and will also enable us to make a comparison with the feldspars of No. 2 crystallizing earlier.

Here the normal feldspar is an andesine or oligoclase, replacing the normal labradorite of quarry No. 2. In order to get an estimate of the quantity of each mineral compound of quarry No. 2 and No. 3, a sample of each was taken, crushed finer than $\frac{1}{100}$ inch, and the dust washed out, then separated with the magnet and solution, with the following results, as the magnet was strong enough to remove the secondary oxide of iron granules formed by the decomposition of diallage: in getting the total per cent of diallage this magnetic portion must be considered, but is given separately here.

	Quarry No. 2.	Quarry No. 3.
Magnetite	4·1	6·
Magnetic	3·6	9·7
Diallage	45·6	41·
Feldspar, G. > 2·69	32·2	23·1
Feldspar, G. < 2·69	14·3	13·4
Feldspar, G. < 2·60	0·	6·5

The decrease in the density of the feldspars from No. 2 to No. 3, or their increase in acidity is clearly shown by the above figures. The total feldspars in No. 2 is 45 per cent; 69 per cent of this is denser than 2·69, and 31 per cent lighter than 2·69, while it all falls before the solution reaches the density of 2·60. The total feldspars in No. 3 is 43 per cent, 53·7 per cent is denser than 2·69, and 46·3 per cent below the density of 2·69; of this 67·3 per cent is denser than 2·60, while 32·7 per cent is below the gravity of 2·60.

In the crystallization of the feldspars, the tendency is to form the anorthite molecule at the border region, but that has not been reached, as the optical properties of the crystals in this region are those of a feldspar of the composition of bytownite, a feldspar richer in CaO than any of the samples analyzed; this is also substantiated, as the analyses of the rock in this region indicates a 10 per cent increase in CaO. From the bytownite molecule the amount of CaO has gradually decreased until in quarry No. 3, the last region to consolidate, a feldspar almost free of CaO has been formed, with a large percentage of K_2O. Thus the feldspars of the Rocky Hill dike present a complexity far greater than has yet been noted in connection with the Mesozoic trap.

Conclusion.

1st. The Rocky Hill trap, from its holocrystalline nature, would be classed as a dolerite.

2d. The border region possesses the ophitic development of its plagioclase; if the small amount of olivine present be considered, it would present the structure and composition of an olivine diabase.

3d. The slow cooling to which it has been subjected coupled with tendency of the anorthite molecule to separate at a higher temperature, has concentrated the more acid feldspars in the portion last to consolidate, to such an extent that its mineralogical composition is almost that of a diorite.

4th. From the character of the decomposition of the olivine, and the solution cavities in the diallage crystals, the intrusive nature of this dike is without doubt, as this must have taken place at considerable depths from the surface, and under very heavy pressure.

John C. Green School of Science, Princeton University,
New Jersey, June, '99.

Literature Cited.

[1] For analyses see: G. H. Cook, Geology of New Jersey, 1868; G. W. Hawes, Trap Rocks of the Conn. Valley, this Journal, 3d series, vol. ix; H. D. Campbell and W. G. Brown, Geol. Soc. of Am., Bull. 2, 1891, p. 346; Dr. F. A. Genth, 2nd, Geol. Survey of Pa., Report on progress in York and Adams Co., p. 120.

[2] J. D. Dana, this Journal, 3d series, vol. ix, p. 191.

[4] G. W. Hawes, Proc. U. S. National Museum, vol. iv, 1881, p. 132.

[5] H. D. Campbell and W. G. Brown, l. c., p. 341.

[6] See New Jersey Geol. Report for 1896, p. 34.

[7] N. H. Darton, Bull. U. S. Geol. Sur., No. 67.

[8] E. C. E. Lord, Am. Geologist, vol. xxii, No. 6.

[9] J. P. Iddings, this Journal, 3d ser., vol. xxxi.

[10] Zeitschr. d. d. Geol. Ges., xxiii, 1871.

[11] J. W. Judd, Quart. Jour. Geol. Soc., xli, 1885, pp. 381 and 382.

[12] H. C. Lewis, The Genesis and Matrix of the Diamond.

[13] G. H. Williams, Bulletin No. 38, U. S. Geol. Survey.

[14] W. H. Winchell, Determinations of the Feldspars, Am. Geo., vol. xxi, p. 31.

[15] Mineral Resources of the U. S., 18th, p. 958.

[16] This Journal, vol. ix, 1875, p. 327.

[17] Dana's System of Mineralogy, p. 327.

[18] G. Tschermak, Ueber Pyroxene und Amphibole, T. M. M., 1871–17.

[19] F. Beche; Experimentelle Untersuchungen über die Bildung der Minerale in Magma, T. M. M., xviii, p. 124.

[20] J. H. L. Vogt, Beiträge zur Kenntniss der Gesetze der mineralbildung in Schmelzmassen, etc., Kristiania, 1892.

[21] Dana's System of Mineralogy, p. 327.

[22] See Iddings-Rosenbusch, p. 300.

[23] E. H. Williams, Jour. of Geol., vol. i, p. 176.

[24] Dana's System of Mineralogy, p. 324, No. 8.

ART. XXXI.—*Some Analyses of Italian Volcanic Rocks;* by HENRY S. WASHINGTON. I.

DURING the past two years I have made a number of analyses of Italian volcanic rocks, with the intention of incorporating them in a general article on the subject. As, however, other work has come up which will delay this indefinitely, it has been decided to publish them. Isolated analyses of rocks, without discussion of their relations to those of other connected types, are of little use. But they may prove of service to others investigating this region, and personally I would like to clear out this pigeon-hole.

Trachytes of the Phlegræan Fields.—The material composing the cone of Monte Nuovo, which was formed in 1538, is largely pumice and lapilli, but blocks of dense lava from a flow are found in a quarry on the southern slope, and it is from these that material was taken for analysis.

The rock is compact and very fine-grained, with a rough feel. The color is ash gray, with streaks of lighter gray. A few small glistening phenocrysts of alkali-feldspar are visible.

Under the microscope specimens vary considerably, but all belong to the Ponza type of Rosenbusch. The structure is hyalopilitic trachytic. Long slender prisms of alkali-feldspar are abundant, often split and branching as has been described in the case of some Ischian trachytes.* They are elongated parallel to the axis *à*. Small elongated crystals of ægirine-augite and grains of magnetite are present in less amount. All these, with dusty grains, lie in an isotropic glass-like groundmass, which is usually colorless, but often a light brown, especially in patches. This base gelatinizes readily with HCl, and must be largely composed of the sodalite molecule, since it is the only constituent which could carry the notable amount of Cl found. I could find no trace of the anorthite and olivine mentioned by dell'Erba,† nor of the leucite spoken of by vom Rath‡ as having been found by G. Rose.

The specimen of the Monte Cuma trachyte was obtained from the large quarries at the west foot of the ancient acropolis. It is similar in appearance to the preceding, showing also a eutaxitic structure, though here the streaks are darker, and minute pyroxene phenocrysts are common.

Microscopically it differs considerably from that of Monte Nuovo. Prismatic phenocrysts of alkali-feldspar, elongated

* H. S. Washington, this Journal (4), i, p. 375, 1896.
† dell'Erba, Boll. Com. Geol. Ital., 1894, p. 197.
‡ Vom Rath, Zeitschr. d. d. Geol. Ges., xviii, p. 613, 1866.

parallel to *à*, are abundant, their borders tending to shade off into the groundmass. Smaller, longish crystals of a pale green, very slightly pleochroic ægirine-augite are very abundant. Few, if any, of the separate individuals of ægirine mentioned by Rosenbusch* could be seen. The groundmass proper is composed of small rude laths and anhedra of alkali-feldspar, with grains of magnetite and ægirine-augite. Interspersed with these are small, colorless, isotropic anhedra, which gelatinize with HCl and stain readily. These must be referred to sodalite, which the analysis shows is present to the extent of about ten per cent. No glass base could be found and the specimen analyzed is quite holocrystalline. A dense, black, glassy obsidian, carrying many feldspar phenocrysts, is also found at the locality in small amount.

Vom Rath speaks of sodalite in the groundmass as "unvollkommen ausgeschieden," and describes the sodalite which occurs in the crevices of the rock. He also mentions a scapolite-like tetragonal mineral as very abundant in the groundmass, and, from his analysis, comes to the conclusion that it has the composition of oligoclase.† My microscopical exami-

	I	II	III	IV	V
SiO_2	60·33	59·79	61·71	59·47	61·23
TiO_2	trace	trace	----	----	----
Al_2O_3	18·74	19·71	16·85	17·24	18·42
Fe_2O_3	2·84	2·95	4·27	4·33	----
FeO	1·29	1·08	----	----	4·55
MnO	trace	trace	trace	----	----
MgO	0·38	0·36	0·99	0·99	0·34
CaO	1·15	1·19	1·51	3·10	1·81
Na_2O	7·15	6·79	7·50	6·17	10·82
K_2O	7·30	7·10	4·36	8·01	2·62
H_2O	0·56	0·24	1·05	1·07	0·16
Cl	0·43	0·53	0·65	1·03	0·78
	100·17	99·74	98·89	101·41	100·73
O = Cl	0·11	0·13	0·16	0·24	0·18
	100·06	99·61	98·73	101·17	100·57

I. Trachyte, Monte Nuovo. H. S. Washington anal.
II. Trachyte, Monte Cuma. H. S. Washington anal.
III. Monte Nuovo. Abich anal. Abich. Vulk. Ersch., 1841 p. 39. Recalculated in Roth. Gest. Analysen, 1861, p. 18, No. 9.
IV. Monte Nuovo. Rammelsberg anal. Roth. Gesteins-Analysen, 1861, p. 18, No. 10.
V. Monte Cuma. Vom Rath anal., op. cit., p. 610.

* Rosenbusch, Mikr. Phys., ii, 1896, p. 750.
† Vom Rath, op. cit., pp. 608, 612.

nation does not substantiate these observations, nor, from a chemical standpoint, is such an assumption necessary, as will be seen on discussion of the analyses. Vom Rath also describes and figures a fayalite-like olivine which occurs in the crevices. Its occurrence resembles that of fayalite in obsidians of Lipari, described by Iddings and Penfield.*

My two analyses (I and II) resemble each other very closely and are typically trachytic in most features. SiO_2 is about 60, which is rather low for trachytes and approaches the silica content of the phonolites. Al_2O_3 is normal; iron oxides, magnesia and lime are low, with Fe_2O_3 notably higher than FeO in accordance with the presence of the ægirine molecule. The alkalies are high, amounting together to 14 per cent, and molecularly Na_2O surpasses K_2O (the ratios being 1·47 and 1·45), so that both rocks must be held to belong to the sub-group of soda-trachytes.

The two analyses by Abich and Rammelsberg are chiefly of historical interest, since they are obviously at fault in many particulars. That of vom Rath is better, but suffers from a peculiarity elsewhere observed in his rock analyses, viz: too high soda and too low potash.† It was this, together with his higher lime, which led him to infer the peculiar composition of the mineral mentioned above, which may be referred to sodalite, or possibly to marialite. The mineralogical composition of the Monte Nuovo rock cannot be satisfactorily determined, owing to the presence of glass. That of the Monte Cuma trachyte, however, which is holocrystalline, calculates out very nicely from the data given by the analysis and the microscope.

Orthoclase	42·2
Albite	34·4
Sodalite	11·1
Diopside	4·9
Ægirine	6·5
Magnetite	0·9
	100·0

Trachytes of Ischia.—Of these rocks three analyses were made. They are all so well known that a detailed petrographical description seems superfluous. That from Monte Rotaro is the black vitreous rock containing sheaf-like ("keraunoidal") alkali-feldspars already mentioned. The Monte Marecocco lava is light gray with many large phenocrysts of alkali-feldspar, a typically trachytic groundmass of feldspar laths, diop-

* Iddings and Penfield, this Journal (3), xl, p. 75, 1890.
† Cf. H. S. Washington, Journ. Geol., v, pp. 351, 357, 1897.

side, ægirine and magnetite grains, and little or no glass. No sodalite could be found, though it is undoubtedly present. The Arso rock is the well-known black one with numerous feldspar phenocrysts. It is notable through its small though constant content of olivine.

	I	II	III	IV
SiO_2	61·62	61·88	60·77	61·49
TiO_2	0·87	0·69	----	----
Al_2O_3	18·24	18·21	19·83	20·02
Fe_2O_3	2·36	2·19	4·14	3·11
FeO	1·28	1·38	2·43	2·72
MnO	trace	trace	trace	0·01
MgO	0·56	0·61	0·34	0·52
CaO	1·44	1·15	1·63	1·88
Na_2O	5·77	6·89	4·90	3·39
K_2O	7·60	6·72	6·27	7·13
H_2O	0·78	0·37	0·24	0·46
Cl	0·15	0·30	----	----
P_2O_5	----	----	trace	0·02
	100·67	100·39	100·55	100·75
O = Cl	0·03	0·07		
	100·64	100·32		

I. Trachyte, Monte Rotaro. H. S. Washington anal.
II. Trachyte, Marecocco. H. S. Washington anal.
III. Monte Rotaro. Fuchs anal. Min. Petr. Mitth., 1872, p. 232.
IV. Marecocco. Fuchs anal. Min. Petr. Mitth., 1872, p. 229.

The two analyses (I and II) resemble each other very closely, except in the alkalies, though the total amount of these is the same. They are typical trachytes rich in soda, and are practically identical with those of the Phlegræan Fields, as was to be expected from the microscopical examination. The rather high TiO_2 is to be noted, as well as the Cl lower than in the preceding. They resemble on the whole the analyses of Fuchs, though his alkalies are considerably lower. It is probable that his alkalies are too low, since calculation shows that about two per cent more are needed to satisfy the SiO_2 and Al_2O_3 present. Analysis II, of the holocrystalline Marecocco trachyte, calculates out as follows. It seems probable that sodalite is rather too high, since it was not seen in the sections.

Orthoclase	39·5
Albite	47·1
Sodalite	4·7
Diopside	4·6
Ægirine	1·4
Magnetite	2·7
	100·0

Analyses of the Arso lava are given below. Mine agrees fairly well with that of Fuchs, though there are certain differences, notably in the alkalies. His analysis of the scoria of this eruption, from Le Cremate, is lower in SiO_2 and higher in Al_2O_3, but otherwise resembles that of the main part of the flow. Abich's analysis differs in several particulars from the others, and is inserted only for the sake of completeness.

This rock differs markedly from the other trachytes of Ischia, which, as Fuchs has shown, have a very uniform composition. It is much more basic, showing lower SiO_2 and alkalies, and higher FeO, MgO and CaO. The sections also reveal

	I	II	III	IV	V
SiO_2	56·75	57·73	54·83	61·03	57·91
TiO_2	1·24	----	----	----	0·65
Al_2O_3	18·37	17·85	20·17	17·21	15·79
Fe_2O_3	2·22	4·44	4·77	4·84	6·81
FeO	3·04	3·90	3·86		0·01
MnO	trace	----	----	0·17	0·23
MgO	2·02	1·77	1·93	2·07	1·66
CaO	4·68	3·65	4·12	1·43	2·99
Na_2O	4·85	3·67	3·04	4·64	6·01
K_2O	5·92	7·65	7·38	7·16	7·27
H_2O	0·18	0·09	0·46	0·56	0·34
Cl	0·11	----	----	----	0·60
P_2O_5	----	trace	----	----	0·01
	99·38	100·85	100·56	99·11	100·27
O = Cl	0·03				0·14
	99·35				100·13

I. "Ciminite," Arso, Ischia. H. S. Washington anal.
II. Ditto, Arso. Fuchs anal. Min. Petr. Mitth., 1872, p. 230.
III. Scoria, Le Cremate. Fuchs anal., op. cit., p. 231.
IV. "Ciminite," Arso. Abich anal., Vulk. Ersch., 1841, p. 44.
V. Sodalite-Trachyte, Monte Santo, Naples. Johnston-Lavis anal. Geol. Mag. (III), vi, p. 77, 1889.

the presence of some olivine and considerable basic labradorite. The rock, therefore, is not a typical trachyte, and was placed by me among the group of ciminites recently described.* It, however, does not contain as much MgO and CaO as these do normally, and might better be considered as transitional between them and the normal trachytes.

In a recent paper† Rosenbusch describes the minerals lining the crevices of this rock, which include alkali-feldspar, sodalite,

* Jour. Geol., iv, p. 834, 1896 and v, p. 351, 1897.

† Rosenbusch, Ueber Eutolith, etc., Sitz. ber. Akad. Wiss., Berlin, 1899, p. 111, note 1.

magnetite, biotite, augite, hypersthene and apatite. He remarks that this association, with the chemical and mineralogical characters of the rock, points conclusively to its relationship with the monzonites and essexites.

In connection with this rock it is interesting to note the composition of the sodalite-trachyte described by Johnston-Lavis, an analysis of which is given in V. The rock occurs west of Naples, near the Phlegræan Fields. It carries sodalite and hornblende, and, although it is not stated to contain olivine, in chemical composition it resembles very much the Arso rock, indicating a similarity in composition and differentiation of the magma at the two centers.

General Relationships.—This is not the place for a general discussion, but a few words may be devoted to the relationship of the rocks whose analyses have just been given to those of the other Italian volcanoes. The apparently justifiable assumption is made that these analyses fairly represent the composition of the rocks of the Phlegræan Fields and Ischia.

It is well known that the main line of Italian volcanoes has erupted rocks which are characterized chemically by high potash and lime, and that leucitic rocks are abundant.* It has also been shown that the rocks of this line belong to two main groups: the leucitic rocks, which are either basic (leucitites and leucite-tephrites) or intermediate (leucite-trachytes), and latites† (intermediate between trachytes and andesites or basalts), characterized by the presence of both orthoclase and plagioclase. In all these rocks the ratio of K_2O to Na_2O is constantly greater than unity, sometimes much so, and CaO is also high.

It is seen from the analyses given in the preceding pages that at Ischia and the Phlegræan Fields the rocks are chemically quite distinct, Na_2O being here constantly higher than K_2O, CaO being low, and leucite absent, or at least very rare.‡ They also tend to be rather high in SiO_2.

While they differ from the rocks of the peninsula, they show certain analogies with the volcanic rocks of the islands which lie along the west coast of Italy,—those of Capraia,§ the Ponza Islands,‖ the Lipari Islands,¶ and perhaps Etna** and the Val

* Cf. Journ. Geol., v, p. 376, 1897.

† Ransome, this Journal (4), v, pp. 355, 372, 1898.

‡ Leucitic rocks have been observed as blocks in tuff at Monte di Procida and one or two other places in the Phlegræan Fields. They are not abundant, and their relations with the main trachytic rocks are uncertain.

§ H. Emmons, Q. J. G. S., xlix, p. 129. 1893.

‖ Doelter, Denkschr. k. Akad. Wiss. Wien, xxxvi, p. 1, 1875.

¶ Cortese and Sabatini, Descrizione delle Isole Eolie. Rome, 1892.

** v. Lasaulx in vom Waltershausen der Ætna, Leipzig, 1880, ii, pp. 425 ff. Ricciardi, Gazz. Chim. Ital., xi, p. 149, 1881.

di Noto in Sicily.* It is impossible here to go into a description of all these, for which the reader may turn to the references given. It must suffice to state that at Capraia we find andesites, at the Ponza and Lipari† Islands rhyolites, trachytes, latites and a few basalts, while at Etna‡ and Val di Noto there have been erupted only normal basalts of a fairly uniform composition. From the analyses of the rocks of these localities it is evident that they differ also chemically from those of the Bolsena-Vesuvius line, Na_2O being higher than K_2O (except in the rhyolites), though here also CaO is apt to be rather high.

Consideration of these facts leads to the conclusion that the rocks of Ischia and the Phlegræan Fields are related rather to those of the other islands than to those of the main Bolsena-Vesuvius line, and, while the data at hand are perhaps insufficient, I would express the view that they are not genetically connected (at least in an immediate way) with the closely adjacent rocks of Somma and Vesuvius.

The idea that a volcanic fracture-line exists west of the Italian peninsula was first broached by Pilla in 1842, supported by Doelter and Suess, expressed in a somewhat modified form by Ponzi, and has lately been taken up by Ricciardi.§ This last writer bases his conclusions partly on stratigraphical observations, but largely in a chemical way on the amount of SiO_2 in the various rocks.

That the amount of SiO_2 alone is not a proper nor sufficient basis on which to compare rocks of various regions is a fact that will scarcely be disputed by any petrographer. But from a broader point of view, embracing all the chemical and mineralogical characters of the various rocks, as well as from other, topographical, vulcanological and stratigraphical considerations, it would seem that the conclusion is justified that a volcanic fracture-line exists west of the coast of Italy and parallel with it, extending from Capraia, through the Ponza Islands, Ischia and the Phlegræan Fields, the Lipari Islands, and ending probably in Sicily at Etna and Val di Noto.

* Ricciardi, Gazz. Chim. Ital., xl, p. 171, 1881.

† It may be remarked that I have been able to find no good analysis of the well known rocks of these islands, with the exception of one of an apparently abnormal type described by Hobbs (Bull. Geol. Soc. Am., v. p 599, 1893), those of Abich (Vulk. Ersch., 1841, pp. 25, 62) and of Baltzer (Zeit. d. deut. geol Ges., xxvii, p. 36, 1875) being too obviously incorrect to merit consideration—a striking instance of the imperfection of our chemical knowledge of igneous rocks.

‡ Johnston-Lavis (Boll. Soc. Ital. Micro. Acireale, i. p. 26, 1888) has detected leucite in one of the basalts of Etna and Bäckström (Geol. Fören. Förh., xviii, p. 155, 1896), in rocks from Volcanello.

§ Ricciardi, Sull' Allineamento dei Vulcani Italiani. Reggio-Emilia, 1887. References to the other authorities cited may be found in this paper, as also a map.

The main vulcanological fact on which this conclusion rests is the similarity between the two lines in the order and direction of extinction along them. Space is lacking for detailed statement, but in both we find the volcanic activity dying away from north to south. Thus the volcanoes of Bolsena and Viterbo are older than those of the Alban Hills, where eruptions took place not much anterior to the earliest Roman times, and perhaps also during the Roman Republic. At the Ernici and Rocca Monfina the evidence is uncertain, but at the southern extremity there is the still active volcano of Vesuvius.

Similarly along the western line we find to the north the much denuded remains of old volcanoes at Capraia, Elba and Giglio. At the Ponza Islands the original forms are better preserved, though extensively denuded. At the Ischian region the forms are more perfect and activity is almost ended, as shown by the eruptions of the Solfatara, Monte Nuovo and Arso, and other facts. At the Lipari Islands we find also the remains of large volcanoes, and activity is still kept up to a certain extent at the small vents of Vulcano and Stromboli.* At Etna alone, near the extreme south end of the line, do we find a typical volcano, in a comparatively perfect state and in full activity,—comparable with Vesuvius.

It may also be noted that there seems to be a tendency for the later lavas to be more basic than the earlier, as has been pointed out in general for the Bolsena-Vesuvius line,† and as may be exemplified by the rocks of the Alban Hills, Vesuvius, Stromboli‡ and Etna.

That the petrographical provinces of the Bolsena-Vesuvius line and of the groups of Ponza, Ischia, the Lipari Islands and Etna are quite distinct is well known,§ but it is less generally supposed or accepted that a well marked line exists—now largely covered by the waters of the Mediterranean—which is parallel to the other and quite distinct from it, and that the rocks of Ischia and the Phlegraean Fields are not genetically connected with those of the neighboring Vesuvian vent.

In this connection it may be suggested as a tentative hypothesis that another parallel fracture-line is to be found to the southwest, which extends from the small islets of Linosa and Lampedusa, southwest of Malta, through Pantellaria to Sardinia. Concerning the first two islets our information is of the scantiest, it being only known that they are volcanic.‖ Rosen-

* Cf. Bonney, Volcanoes, 1899, pp. 198–201.

† Cf. Journ. Geol., v, p. 376, 1897.

‡ Cortese and Sabatini, op. cit., p. 81. The rocks of Vulcano are also generally basic, but those of the last eruption are rather acid. (Op. cit, p. 114.)

§ Cf. Bonney, Volcanoes, p. 197.

‖ Scrope, Volcanoes, 1862, p. 345.

busch* has pointed out the close resemblance between the pantellerites of Pantelleria and the commendites of San Pietro on the southwest coast of Sardinia, which, as well as the other rocks of Pantelleria, are high in Na_2O.† At the volcano of Monte Ferru‡ in Sardinia Doelter found the rocks to be trachytes, phonolites and basalts (with some leucite-basalts), which, according to his analyses, show Na_2O (molecularly) uniformly higher than K_2O, and in some cases very high.

It would seem, then, from these rather insufficient and summarily given facts, that we have in the Italian district three parallel volcanic lines. The latest, along the peninsula, is characterized chiefly by high K_2O, as well as high CaO, and by the presence of leucite. The next, that of the islands along the west coast, is also high in alkalies but with Na_2O rather higher than K_2O, and without leucite. The third, which lies far out in the Mediterranean, and which is possibly the oldest, is much higher in Na_2O and seems to be characterized by the presence of peculiar soda minerals, such as ænigmatite and ægirine, nepheline also occurring in places. The relations of the three main centers exterior to these lines, those of the Euganean and Berici Hills and Monte Vulture, are uncertain and need not be discussed here.

Aug. 1, 1899.

* Rosenbusch, Mikr. Phys., ii, 1896, p. 614.

† We cannot determine this point in regard to the other rocks of San Pietro, as Eigel (Min. Petr. Mitth., viii, p. 73, 1886) unfortunately did not determine the alkalies separately.

‡ Doelter, Abh. Akad. Wiss. Wien., xxxviii, p. 41, 1878.

Art. XXXII.—*Mineralogical Notes: Melonite (?), Coloradoite, Petzite, Hessite;* by W. F. Hillebrand.

In a suite of tellurides from the Mother Lode region in California, collected by Mr F. L. Ransome, of the Geological Survey, I have been able to identify a nickel telluride (melonite ?), a mercury telluride (coloradoite ?), besides petzite and hessite.

Melonite ?

Several specimens from the old Stanislaus mine,* the original source of Genth's melonite† (Ni_2Te_3 ?), but now included with the Melones and other claims under the name Melones mine, showed plainly a nickel telluride of reddish white cast of color like that of bismuth,‡ thickly scattered in grains and showing pronounced cleavage and a brilliant luster. A concentrate was prepared by the aid of cadmium-boro-tungstate solution, and this was then laboriously hand-picked by the aid of a powerful glass. There was certainly more than one foreign mineral present, but identification was not possible with exception of a little gold and petzite. The chief impurity was a silver mineral, presumably hessite. If so, the analyses seem to indicate also native tellurium. A perfectly pure article could not be extracted because of difficulty in sometimes distinguishing the foreign minerals from the one sought, but it was hoped that an analysis of both the selected and rejected portions would permit of calculating the composition of the nickel mineral with considerable certainty on the reasonable assumption that no impurity had been removed in relative excess over the other or others.

* Mr. Ransome has kindly furnished the following notes:

"This mine is situated on the south slope of Carson Hill, Calaveras Co., just above Robinson's Ferry, and has not been worked for several years. There is no prominent vein at this point, the ore being very irregularly distributed, and occurring in small nearly horizontal stringers in dark clay slates of Carboniferous age with nearly vertical dip. This mine has long been known as a source of interesting tellurides, and Dana, in the sixth edition of his System of Mineralogy, cites petzite, calaverite, melonite, and altaite as occurring here. The other ore minerals are pyrite and galena, the latter in small quantities. The ore-bearing stringers are filled with quartz, or a mixture of quartz and calcite as a gangue. The rich masses of tellurides appear, however, to be usually associated with calcite (or dolomite). The melonite of specimen No. 16 shows at least one perfect cleavage, resembling in the thinness of the resulting laminæ the cleavage of the micas. The cleavage faces are usually somewhat curved, and possess a splendent metallic luster. (The cleavage can best be detected by carefully scraping thin folia from such a brilliant surface with a sharp knife point.) The color of the cleavage faces is pale bronze-yellow."

† Long *o* accented.

‡ Under a lense and to the unaided eye in certain lights the color appears more bronze-yellow.

The analyses below represent the composition of (*a*) the rejected, (*b*) the original, and (*c*) the selected material. Analysis (*b*) is given chiefly because of the cobalt determination, the nickel being probably a little high. Although but 0·22 and 0·13 grams respectively were available for the analyses (*a*) and (*c*), the data are believed to be more trustworthy on the whole than those of (*b*), hence the figures under (*d*) have been obtained by calculation based on (*c*) and (*a*) only, after reducing them to 100. Under (*e*) is shown the theoretical composition of $NiTe_2$. Small amounts of iron, traces of copper, and perhaps of one or two other elements are omitted, besides the ¾–2 per cent of gold and petzite that remained unattacked by cold dilute nitric acid in which the nickel mineral is readily soluble.

The specific gravity of (*b*) at 22·5 was 7·72, which is probably higher than the true density of the pure nickel telluride.

	a	*b*	*c*	*d*	*e* $NiTe_2$
Te	75·29	77·72	80·75	81·40	81·29
Ni, Co	15·71	17·16 + ·10	18·31	18·60	18·71
Ag	8·44	5·09	·86		
	99·44	100·07	99·92	100·00	100·00

If hessite and native tellurium constitute the foreign admixture, the mineralogical composition of (*a*) and (*c*) is shown to be as follows:

	a	*c*
$NiTe_2$	84·44	97·89
Hessite	13·51	1·38
Tellurium	2·05	·73
	100·00	100·00

There is here indicated a considerable selective separation of the foreign minerals, since the relative proportions of tellurium and hessite are very different in the two mixtures, but the amounts operated on were so small that a very slight actual error in a determination might give rise to this change in the relative proportions of impurities without affecting materially the ratios found for the components of the nickel telluride. The three analyses taken together point unmistakably to $NiTe_2$ as the formula for the latter mineral. The question then arises, is this Genth's melonite, or is it a new mineral? Genth found

Te	73·43
Ni	20·98
Ag	4·08
Pb	·72
	99·21

from which, after deducting hessite, altaite, and free tellurium, he deduces the formula Ni_2Te_3, requiring Te 76·49 and Ni 23·51.

The difference between this and my own analyses is too great to admit of bringing them into accordance, yet I am indisposed to believe that two minerals are represented, for both occurrence and appearance are opposed to such a view. The present mineral is from the same source as Genth's, its physical characteristics, so far as ascertainable, coincide with those of melonite, and it is called melonite by the people at the mine. Melonite was considered by Genth to be hexagonal on the strength of its eminent cleavage and the observation of a single microscopic six-sided plate. Mineralogically a hexagonal form in the pyrite group, assuming this mineral to belong there, is not to be looked for, but the evidence in favor of hexagonal crystallization is too meager to permit this to be used as an argument one way or another.

Coloradoite?

One small specimen from the Norwegian mine showed in dolomite, petzite, hessite, and a mercury telluride. Superficially the latter was not to be distinguished from the accompanying petzite and hessite, and it was in insufficient amount to admit of analysis for the determination of its formula. It, however, gave the tests noted by Genth for the original coloradoite from Colorado, and in addition the following characteristic may be noted. On heating with strong nitric acid it becomes coated with a white insoluble salt of mercury, which retards further action of the acid.

It is in all probability coloradoite, and if so this is its second known locality of occurrence, though I have been informed that a mercury telluride has recently been found in Western Australia.

Petzite.

One specimen of petzite from the Norwegian mine gave such an abundance of pure material that an analysis seemed desirable.

The results were as follows:

		Ratios.	
Au	25·16	1·98	1·00
Ag	41·87		3·04
Te	33·21	1·00	
Se	trace		
Mo	·08		
	100·32		

Approximate specific gravity at 23° C. 8·925. The molybdenum may exist as sulphide. The ratios lead almost exactly to the formula Au_2Te, $3Ag_2Te$.

Hessite.

In conclusion may be given an analysis of hessite from a new locality, San Sebastian, Jalisco, Mexico, the material being received from Mr. Frederic Chisolm.

Specific gravity at 26° C. 8·24

Ag	61·16	
Te	36·11	
Pb	1·90	
S, Fe, Zn	·83	(difference)
	100·00	

Laboratory of the U. S. Geological Survey, June, 1899.

Art. XXXIII.—*Note on Epidote and Garnet from Idaho;* by Chas. Palache.

In the fall of 1898 Messrs. C. L. Whittle and Wm. Beals, Jr., presented to the Harvard Mineralogical Museum a suite of mineral specimens collected by them in the Seven Devils Mining District, Idaho, chiefly from the Peacock and White Monument mines. The ore of these mines is argentiferous chalcocite and bornite; these specimens, however, show but little ore material, being composed almost wholly of the associated vein minerals, among which were determined: (1) from the Peacock Mine—epidote, almandite garnet, quartz, chrysocolla, malachite, brochantite, hematite, and chlorite; (2) from the White Monument Mine—calcite, malachite, melaconite, grossularite garnet, and epidote; (3) from the Copper Key Mine—andradite garnet.

The Peacock Mine was the source of the powellite first described by Melville;* the specimens were therefore carefully searched for that mineral but none was found.

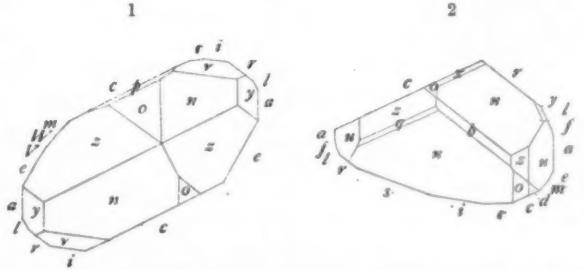


Fig. 1. c (001), a (100), m (102), W (305), V (405), e (101), σ ($\bar{1}03$), i ($\bar{1}02$), r ($\bar{1}01$), l ($\bar{2}01$), z (110), o (011), p (016), n ($\bar{1}11$), y ($\bar{2}11$), η ($\bar{2}12$).

Fig. 2. c (001), a (100), b (010), e (101), m (102), f ($\bar{3}01$), l ($\bar{2}01$), r ($\bar{1}01$), s ($\bar{2}03$), i ($\bar{1}02$), σ ($\bar{1}03$), z (110), u (210), o (011), n ($\bar{1}11$), x ($\bar{1}12$), d (111), q ($\bar{2}21$).

Epidote.—Epidote is the most abundant and most interesting mineral present. It is in well developed crystals lining the walls of cavities in massive epidote. The crystals are dark green in color and often of large size, the largest collected being two inches in length and breadth. Mr. Whittle saw a cavity in which a large number of perfect crystals upwards of a foot in length had been destroyed by the miner's pick.

The crystals have the normal epidote habit, prismatic parallel

* W. H. Melville, this Journal, xli, 1891, page 138.

to $\bar{b}$, and are generally flattened parallel to the basal plane so that lense-shaped cross-sections are common; they are invariably implanted on an end of the orthoaxis, $\bar{b}$. The majority of the crystals are terminated simply by n ($\bar{1}11$), sometimes together with b (010), and in the orthodome zone show c (001), i ($\bar{1}02$), r ($\bar{1}01$), and a (100). A few crystals, however, showed a much richer series of forms as seen in figs. 1 and 2, which are orthographic projections on the clinopinacoid and reproduce the distortion of the crystals.

Twinning was observed on several crystals according to the usual law: twin plane a (100). In one crystal the twinning was repeated, two narrow lamellæ intervening between the two principal individuals.

Many of the crystals exhibit a strong tendency to scale off in concentric shells parallel to all the crystal faces. This was particularly noticeable in the crystals figured above, even the smallest faces preserving their luster and permitting good measurements after the surface layers had been removed. The shelly structure sometimes gives rise to a brilliant iridescence on the faces of the crystal and is generally associated with a bleaching of the color, presumably due to surface alteration.

Some of the epidote crystals are imbedded in quartz of later growth, the latest deposit in the cavities. A single specimen from the Decorah Mine showed such imbedded crystals of a pale green epidote which were exceptional in being doubly terminated.

The epidote is in places largely changed to a scaly chloritic material which was not further examined.

Garnet.—The garnet from the Peacock Mine is almandite, probably the same as that analyzed by Melville* from the same locality. It is in light to dark brown, completely developed, and very symmetrical crystals showing the forms d (101), p (211), and sometimes s (321). They are imbedded in glassy copper-stained quartz from which they easily separate, leaving beautifully sharp casts.

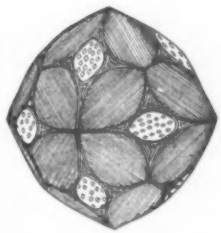
A second type of garnet is found in the Peacock Mine specimens. Rough crystals an inch or less in diameter show a pronounced dodecahedral form, the edges slightly truncated by the icositetrahedron (211). The centers of the crystals are of a dark brown garnet substance; but the exterior is uniformly coated with a shell of clear quartz $\frac{1}{2}^{mm}$ in thickness conforming in minutest detail to the form of the garnet crystal. A thin section through such a crystal showed that the quartz in one of these shells formed but a single crystal, and it appears to represent an original crystallization controlled in the disposition of

* Loc. cit., p. 138.

its material by the garnet crystal. Outside of the quartz is in many instances a similar coating of light green iridescent epidote and here and there thin plates of hematite are arranged between the layers of quartz and epidote. Calcite has also formed similar layers in some crystals and where afterwards removed by solvents leaves the crystals cavernous. The surfaces of the garnet crystals, whether coated with quartz or epidote, are smooth and plain and the effect on looking at an unbroken crystal is as of pseudomorphs of these two minerals after the garnet.

In specimens from the White Monument Mine, crystals of cinnamon-brown grossularite garnet showing only the form p(211) are associated with a little epidote in an impure limestone. In these garnets layers of crystalline calcite are interpolated as in the last described crystals, with the difference that here the outer layer is of garnet substance.

3



Crystals of brown andradite garnet from the Copper Key Mine are notable for the etching which they have undergone. The forms originally present were d(101) and p(211) in almost equal development and perfectly symmetrical. But as shown in fig. 3, the crystals have been much rounded by deep corrosion of all the edges, the solvent action having been greatest at the ends of the trigonal axes where uneven facets have been produced. Shallow rounded grooves replace the edges between d and p and a rounding of the angles at the ends of the axes gives in some cases an approximation to a cube face. The etch facets would give no measurable reflections but their position shows that they are in part trisoctahedrons and in part hexoctahedrons. The faces of both d and p still retain a brilliant luster, but the former are marked by beautifully sharp and symmetrical etch pits of rhombohedral outline, their edges parallel to the dodecahedral edges of the crystal; and the faces of p are grooved quite deeply parallel to the same edges.

A large specimen of vein material from the White Monument Mine consists of large cleavage rhombohedrons of calcite, each of which serves as a core to a spherical layer of radial fibrous calcite. The curved outer surface of these layers is a drusy one formed by sharp calcite rhombohedrons, which in its turn is coated over with a thin layer of quartz crystals. The interspaces between the spheroidal masses are filled with a mixture of dead black melaconite and green chrysocolla with a small amount of malachite.

Chrysocolla and malachite occur throughout the specimens as coatings on epidote or other crystals and in tiny veinlets which penetrate all the interstices of the other vein minerals.

Brochantite was found in several specimens in slender transparent emerald-green prisms or in radial-fibrous aggregates interspersed among the epidote crystals.

Hematite has been already mentioned as forming thin plates parallel to faces of the larger garnets; similar plates are found in the massive epidote and in quartzose portions of the vein.

Mineralogical Laboratory, Harvard University.

Art. XXXIV.—*On Thermoelectricity in Certain Metals;* by Ludwig Holborn and Arthur L. Day.

[Communication from the Physikalisch-Technische Reichsanstalt, Charlottenburg, Germany. Laid before the Königlich Preussische Akademie der Wissenschaften, Berlin, July 20, 1899.]

In connection with the investigation of the gas thermometer at high temperatures and the application of thermo-elements of the platinum metals to the comparison of its results, the need of a law which should accurately express the relation between the electromotive force developed by the latter and the temperature became strongly felt. Theoretical considerations led us to carry the research further, and include the lowest available temperatures as well; thus the range of the investigation became so broad that the behavior of thermo-elements was shown in a much clearer light than heretofore, as will be seen from the following brief sketch of the results.

Avenarius, as is well known, was the first to show that the electromotive force of a thermo-element, expressed as a function of the temperature, approximated very closely to a parabola, and this result has been confirmed for various temperature ranges by Tait, Knott and MacGregor, and Noll. Up to the present time, however, the agreement can be said to be satisfactory only between 0° and 300–400°, and even here several metals show considerable irregularities. Attempts have even been made recently to apply logarithmic formulæ where the difference in temperature between the junctions was large.

The thermo-elements which we have investigated have not, to be sure, followed the law of Avenarius in every case over the entire measured temperature domain, but within very wide limits the agreement is so astonishingly exact that the failure of the law to apply further can only be regarded as an evidence of some change in the condition of the metal investigated at that point—perhaps due to the absorption of gases. The great range of temperature to be covered by this investigation made it only possible to include metals which remain chemically unchanged at high temperatures, i. e., the platinum group together with gold and silver. Thanks to the kind assistance of the firm of Heräus in Hanau and the chemical laboratory of the Reichsanstalt, especially Prof. Mylius, we were able to lay much emphasis upon the chemical purity of the metals investigated.

One of the best means of testing the purity of a metal is often the measurement of its electrical resistance. This has

been done in this case; in fact one of the metals—gold*—offers a remarkable example of the effect of slight impurities upon the temperature coefficient of the resistance.

In connection with the pure metals several alloys were also investigated but offered no exception to the application of the law.

The metals, with the exception of iridium and rhodium, were in the form of drawn wires of $0{\cdot}6^{mm}$ diameter; these two were rolled out into narrow rectangular strips slightly larger than the wires. Wires as well as strips were brought to a bright glow electrically before being used and their homogeneity tested by connecting their ends with a galvanometer while lying in the electric oven, the temperature being maintained first at 500°, then at 1000°. Only the two gold wires Au_0 and Au_1 showed any considerable effect, an electromotive force amounting to 60 microvolts being here obtained. The palladium wires behaved somewhat peculiarly, showing an electromotive force of about 150 microvolts when first laid in the oven at 1000° and half as much at 500°; this decreased in a short time to less than a third of the original value. There is an evident connection between this and a phenomenon conspicuous when the wires were first heated as above mentioned; they did not glow uniformly at once, but several sharply defined dark stretches were noticeable which slowly diminished in length and disappeared after some ten minutes, the wire then glowing quite uniformly.

The electric oven consisted of several concentric tubes of clay separated by air spaces, the innermost tube carrying a coil of nickel wire which could be freely heated to 1300°.

The elements were heated in a porcelain tube which extended through the oven without being in contact with it except on the outside where the cold projecting ends were supported. The hot junction lay in the middle of the oven, and the wires, carefully insulated from each other, were carried out at the ends to the cold junctions (0°).

For the temperature measurement a platinum—platin-rhodium thermo-element was used which had been compared with the gas thermometer between 0° and 1000°. Assuming that one junction is maintained at 0° while the other is heated to $t°$, it is possible to express the electromotive force of the element between 300° and 1000° as a quadratic function of t within the limits of the errors of observation. Above 1000° the temperatures were obtained by extrapolation of this function.

With this standard element the other elements were severally compared, the four wires being melted together at the hot

* This gold wire (Au_0 of the table) had already shown surprising behavior in its electrical and thermal conductivity—Jaeger and Diesselhorst, Sitz. Ber. Berl. Akad., 1899, p. 719.

junction and the electromotive force of any particular metal then being measured with respect to the pure platinum which with the platin-rhodium formed the standard element and indicated the temperature of the hot junction.

The temperature was held as nearly constant as possible at intervals of about 50° and the electromotive force of the metals in various combinations measured; the values for the exact intervals contained in the table being obtained from these by graphical interpolation.

The table contains first the coefficients a*, $100\,b$, and $10000\,c$ of the formula

$$e = -a + bt + ct^2$$

the thermoelectric potential difference (e) being expressed in microvolts; second, the temperature limits t_1 and t_2, within which the formula has been found to apply; third, the mean temperature coefficient α of the electrical resistance between 0° and 100°; and finally, the differences (calculated − observed) expressed in degrees between the values obtained from the formula and the corresponding observed values of the electromotive force. Where the formula no longer applies the differences are enclosed in parentheses.

It will be seen that with the exception of palladium, the Avenarius formula applies between a definite comparatively low temperature and the highest temperature observed, the difference between observed and calculated values being in the mean less than 1°, smaller, in fact, than the differences observable in the same element under different experimental conditions. In the case of palladium, however, two distinct equations are distinguishable, the one for the lower temperatures (below 400°) and the other for the higher (above 600°), and between the two lies a domain of 200° where neither equation applies. Otherwise the agreement between observed and calculated values is nearly as good as with the other elements except in the case of the alloy 90 Pd, 10 Pt, where at the lower temperatures the sensitiveness is very small. This element in particular is also the only one having a minimum within the temperature domain of these observations, the change in direction falling within the limits where neither of the equations applies.

Regarding the difference between the value of the constants a, b and c for various specimens of the same material, no very useful conclusions can be drawn from the material at hand. In the case of gold the value of a seems to decrease with

* It is evident that when the formula contains a constant term, it cannot apply downwards as far as 0°. If, as is nearly always the case, this constant is negative (for which reason it appears with the negative sign in the formula), it indicates that the curve is too steep to pass through 0°.

	Au_0-Pt	Au_1-Pt	Au_2-Pt	Ag−Pt	Rh_1-Pt	Rh_2-Pt	Ir−Pt	90 Pt, 10 Ru −Pt	
a	644	398	388	0	169	228	84	367	a
$10^2 \times b$	684·9	876·9	892·0	589·1	700·0	734·4	670·0	922·9	$b \times 10^2$
$10^4 \times c$	96·8	84·4	83·4	132·0	68·0	66·8	60·0	15·6	$c \times 10^4$
t_1	300°	300°	300°	0°	200°	250°	100°	300°	t_1
t_2	950°	1050°	1050°	950°	1250°	1300°	1200°	1300°	t_2
a	0·00214	0·00389	0·00397	0·00405	0·00440	0·00446	0·00394	—	a
0°	—	—	—	0·0°	(−24°)	(−31°)	(−12·5°)	(−40°)	0°
50	(−56°)	(−28°)	(−29°)	−1·9	(−12)	(−17)	(− 5·8)	(−25)	50
100	(−30)	(−15)	(−15)	+0·4	(− 6·3)	(− 8·2)	− 1·1	(−17)	100
150	(−15)	(−11)	(− 8·6)	−0·7	(− 2·4)	(− 5·6)	0·0	(− 9·6)	150
200	(− 5·5)	(− 7·0)	(− 4·8)	−1·8	− 0·3	(− 3·2)	+ 0·9	(− 5·0)	200
250	(− 1·8)	(− 3·2)	(− 2·1)	−1·5	+ 0·2	− 1·5	0·0	(− 2·4)	250
300	0·0	− 0·1	+ 0·4	+0·2	+ 1·0	+ 0·1	0·0	0·0	300
350	+ 0·2	− 0·1	+ 0·3	+0·1	+ 0·5	+ 0·4	− 0·2	0·0	350
400	+ 0·3	− 0·1	+ 1·1	+0·4	+ 0·6	+ 1·0	+ 1·2	+ 0·4	400
450	− 0·6	− 0·8	+ 0·1	+0·2	+ 0·5	+ 0·6	0·0	0·0	450
500	− 0·2	− 1·2	+ 0·8	−0·1	+ 0·8	+ 0·6	0·0	− 0·3	500
550	+ 0·2	− 0·1	+ 0·1	+1·0	+ 0·3	+ 0·5	+ 0·2	+ 0·5	550
600	− 0·6	− 0·4	− 0·5	+1·9	+ 0·1	+ 0·5	− 0·1	− 0·2	600
650	− 0·9	+ 1·4	+ 2·0	+1·5	− 0·1	+ 0·1	0·0	+ 0·3	650
700	− 0·7	0·0	0·0	+0·1	− 0·3	+ 0·1	− 0·7	+ 0·3	700
750	− 0·5	− 0·6	− 0·5	+0·1	+ 0·2	+ 0·2	+ 0·1	+ 0·5	750
800	− 0·7	− 1·0	− 1·0	−1·1	− 0·7	− 0·6	− 0·2	0·0	800
850	0·0	− 0·5	− 1·0	−0·9	− 0·1	− 0·6	− 0·6	+ 0·3	850
900	+ 1·1	− 0.2	− 0·3	−0·2	− 0·7	− 1·0	+ 0·1	+ 0·2	900
950	+ 1·7	+ 0·7	0·0	+0·8	− 1·2	− 1·0	+ 0·4	— 0·5	950
1000		+ 1·3	+ 0·1		+ 0·3	− 0·1	+ 0·4	− 0·3	1000
1050		+ 0·4	− 0·4		+ 1·5	+ 0·6	+ 1·0	− 0·1	1050
1100					+ 1·3	+ 0·4	+ 1·0	— 0·3	1100
1150					+ 1·1	+ 0·7	+ 1·6	− 0·4	1150
1200					+ 0·7	+ 0·8	+ 1·7	− 0·9	1200
1250					+ 1·1	+ 1·3		+ 0·2	1250
1300						+ 1·0		− 0·8	1300
Mean	±0·74	±0·74	±0·77	±1·02	±0·76	±0·75	±0·75	±0·40	Mean

	90 Pt, 10 Pd—Pt		10 Pt, 90 Pd—Pt		$Pt-Pd_1$		$Pt-Pd_2$		
a	0	330	0	−596	0	0	0	0	**a**
$10^2 \times$ **b**	216·0	447·6	−211·0	−572·0	499.3	316·2	525·3	340·2	**b** $\times 10^2$
$10^4 \times$ **c**	44·0	1·6	28·0	82·0	44·0	80·8	44·0	82·4	**c** $\times 10^4$
t_1	0°	300°	0°	600°	0°	600°	0°	600°	t_1
t_2	300°	1200°	350°	1200°	350°	1250°	350°	1300°	t_2
a	—	—	—	—	0·00373	0·00373	0·00377	0·00377	*a*
0°	0·0°		0·0°		0·0°		0·0°		0°
50	+ 2·8		0·0		− 3·1		+ 0·4		50
100	+ 1·9		− 5·8		− 0·5		− 0·2		100
150	− 1·4	(−18°)	0·0		− 1·9		− 1·1		150
200	− 2·6	(−10)	+ 4·0		+ 0·2		− 0·4		200
250	− 0·7	(− 4·1)	+18·3		+ 1·6		− 0·5		250
300	+ 3·2	− 0·6	+17·1		+ 2·1		+ 0·8		300
350	(+ 7·8)	+ 0·4	0·0		+ 0·4		− 0·2		350
400	(− 1·8)	+ 1·7		(−24°)	− 0·3	(−15°)	− 0·5	(−13°)	400
450	(−24)	+ 0·4		(−17)	(− 4·5)	(−11)	(− 4·5)	(− 8·9)	450
500	(−36)	+ 0·4		(−12)	(− 8·9)	(− 7·0)	(−10)	(− 5·8)	500
550	(−49)	+ 0·6		(− 4·8)	(−15)	(− 3·0)	(−16)	(− 2·7)	550
600		− 0·2		0·0	(−19)	− 1·6	(−27)	− 1·1	600
650		+ 0·2		0·0		+ 0·1		+ 0·1	650
700		− 0·2		0·0		+ 0·5		+ 0·9	700
750		− 0·6		0·0		+ 1·8		+ 1·5	750
800		− 0·2		−0·5		+ 0·8		+ 0·8	800
850		− 0·8		−0·2		+ 0·1		+ 1·0	850
900		0·0		−0·4		+ 0·5		+ 0·2	900
950		0·0		−0·3		+ 1·1		0·0	950
1000		− 0·4		+1·1		+ 0·9		− 0·7	1000
1050		+ 0·8		+0·6		+ 0·7		− 0·9	1050
1100		+ 0·6		−0·3		− 0·8		− 1·4	1100
1150		+ 0·6		+0·1		− 1·5		− 1·0	1150
1200		+ 0·2		+0·7		− 1·2		− 1·1	1200
1250						− 0.4		− 0·1	1250
1300								+ 0·4	1300
Mean	±2·27	±0·61	(±9·8)	±0·47	±1·61	±1·04	±0·59	±0·91	Mean

increasing purity of the metal, the gold Au_0, according to the chemical analysis, containing 0·09 per cent iron and 0·08 per cent copper, while the two other specimens were very pure.

In order to obtain some idea of the behavior of the thermo-elements below 0°, preliminary observations were made at −80° and −185°, from which it was found that all the elementary metals with the exception of palladium have a minimum in the vicinity of −100°. The difference between observed and calculated values increase as the temperature is diminished, in the case of palladium, however, the value calculated from the first equation agrees very well with the observed electromotive force at −100°.

The observed electromotive force of the several metals in microvolts at the two temperatures mentioned follows, the arrangement being the same as in the large table. For purposes of comparison the values obtained experimentally at 450° and 950° are added.

	950°	450°	−80°	−185°
Au_1	15532	5270	−307	−130
Au_2	15612	5314	−315	−166
Ag	17484	5320	−302	−160
Rh_2	12798	4422	−312	−235
Ir	11688	4146	−320	−283
90 Pt, 10 Ru	9814	4102	−388	−534
90 Pt, 10 Pd	4068	1714	− 87	−106
10 Pt, 90 Pd	2566	−290	+146	+240
Pd_2	10670	3296	−392	−774

The platinum wire of the standard element to which all the others were referred, was further compared with another wire ($a = 0{\cdot}00388$) from the same source prepared with especial care. This latter, as also the wire Pd_2, upon analysis by Prof. Mylius, showed no impurities amounting to 0·1 per cent. The electromotive force of these two platinum wires referred to the same platin-rhodium wire showed a difference of 1° at a temperature of 1000°, while a third wire of pure platinum from another firm differed 12° at the same temperature. The last had, however, a smaller temperature coefficient ($a = {\cdot}00376$) and was in all probability less pure.

SCIENTIFIC INTELLIGENCE.

I. Botany.

1. *Note on Cycadofilices;* by G. R. Wieland (communicated). —This group of ancient plants is held to comprise the genera *Nœggerathia, Medullosa, Cladoxylon, Lyginodendron, Heterangium,* and *Protopitys,* with the Medullosan allies *Colpoxylon* and *Steloxylon.* In addition *Myeloxylon, Alethopteris* and *Neuropteris* are now recognized as appendicular leaf structures. Most palæobotanists regard the group as intermediate in structure between Ferns and Cycads. The literature concerning it is much enriched by the recent paper of Dr. Scott: *On the Structure and Affinities of Fossil Plants from the Palæozoic Rocks.* III. *On Medullosa anglica, a new representative of the Cycadofilices;* by D. H. Scott, F.R.S. (Philosoph. Trans. of the Royal Society of London, 1899). As in the treatment of *Lyginodendron* and *Heterangium* this valuable contribution is accompanied by a full series of photographs illustrating structure. *Medullosa anglica* (from the Lower Coal Measures of Britain) is shown from the study of specimens representing all vegetative organs but the fructification to be the most Fern-like of the *Cycadofilices.* Dr. Scott's discussion of its relationships is very interesting. I quote from his conclusion: "The evidence is gradually accumulating which connects the Cycads (and by a less direct line the other gymnosperms also) with the Ferns. The fossil evidence, very strong by itself, is supported by the morphology of the reproductive organs, and by the great discovery of the multiciliate spermatozoids which we owe to Ikeno and Hirase and to Webber. We thus see that external resemblance is not always fallacious; the Fern-like foliage of *Stangeria,* the 'Maiden hair tree,' pointed in the right direction long before botanists were able to follow the clue."

2. *The Hepaticæ and Anthocerates of California;* by Marshall Avery Howe. Memoirs Torrey Botanical Club, vol. vii, pp. 208, 8°, pl. 88–122. Issued Aug. 5, 1899.—This monograph is the most thorough presentation of the hepatics of any portion of the United States which has yet been published. The main portion embraces a detailed account of the genera and species found in California, with full and exact descriptions of the species supplemented by copious, critical notes on synonymy, distribution, etc., together with keys to the genera and species. In the introduction the author enumerates the different collectors of hepatics of the west coast with notes on their collections, and gives tables showing the comparative distribution of Californian species in the northeastern United States, British Isles, northern and central Europe and northern Asia. The Californian species number 86 as compared with 150 of the Eastern States, a relatively large number when one considers the smaller area covered

by the present treatise and the fact that some portions of California, especially the higher mountains, have not yet been thoroughly explored. While, on the one hand, the small rainfall of the lower districts is unfavorable to the development of a rich bryophytic vegetation, the greater height of the mountains as compared with those of the Eastern States is favorable to such development. Two facts are brought out by the table, viz., the number of species peculiar to the Pacific is proportionally greater than of those peculiar to the region of Gray's Manual, and the hepatic flora of California has more in common with Europe than with the eastern and central United States. The author has not only brought together what was previously known as to the structure and nomenclature of California hepatics, but he has also contributed a large amount of original observations in his descriptions and the accompanying notes, and the large number of illustrations add greatly to the value of this excellent monograph.

W. G. F.

3. *Californian Hypogæous Fungi;* by H. W. HARKNESS. Proc. California Acad. Sci., 3d Series, vol. i, No. 8, pp. 241–292, pl. xlii–xlv. Issued July 8, 1899. — Our knowledge of the hypogæous fungi of the United States has hitherto been very imperfect. Beyond occasional references in mycological writings and in the special papers by W. R. Gerard, we are indebted mainly to the previous papers of Dr. Harkness for what we know about our native species. The present monograph is the first extended treatise on the subject and is destined to become a classic in North American mycology. We are now able for the first time to recognize that, contrary to the general opinion, the hypogæous forms are represented by a large number of species in this country. The detection of hypogæous fungi is very difficult because in nearly all cases they exhibit above ground no evidence of their existence. Long experience and great patience are necessary to discover them and the collections of Dr. Harkness represent the labor of many years. The district examined specially by him extended from the northern State line of California to the Tehachappi range on the south and from the valley of Donner Lake on the east to the Pacific coast. The best locality for most species was found to be the foot hills at an elevation of about 1500 feet and the most productive season was early spring. Rodents it appears are very fond of the mature fungi, and they are especially destructive to forms which grow under Sequoias.

The number of species described is 105 besides three species, *Sphæria Setchellii* Harkness, *S. Zobelii* Tul., and *Sporophaga cyanea*, the type of a new genus, which are parasitic on different Tuberaceæ. Of the 25 genera included in this monograph Leucophleps, Myrmecocystis, Piersonia and Terfeziopsis are new to science. The new species number 56, of which 8 belong to the genus Tuber, 7 to Hymenogaster and 5 to Octaviania and Leucophleps. For a detailed account the reader must be referred to descriptions and notes of Dr. Harkness given in his monograph,

which is illustrated by four folded plates, of which the drawings, in part colored, were made by Dr. Eisen. With regard to the economic value of the Californian Hypogæa Dr. Harkness states that he has found none of the edible varieties of Europe, although *Tuber Californica* is nearly identical with an edible species of Italy. All of the Californian species are edible, but they are so rare that their use is practically out of the question. Notes are however given concerning a species found at Marysville, belonging probably to the genus Terfezia, which grows in large quantities and is esteemed a delicacy. W. G. F.

II. Miscellaneous Scientific Intelligence.

1. *American Association for the Advancement of Science.*— The forty-eighth meeting of the American Association was held at Columbus, Ohio, during the week from August 19th to 26th. The President of the meeting was President Edward Orton of Columbus. The number of members in attendance was not conspicuously large—the total registration being three hundred and fifty-two—but much interest was manifested throughout and the meeting proved as a whole highly successful; the various local committees did all in their power to contribute to this end.

The retiring President, Professor F. W. Putnam, delivered an address on Monday, August 21, upon the subject "A Problem in American Anthropology." Other able addresses were also given by the Vice Presidents of the several sections.* Another feature of the meeting was a public lecture with lantern illustrations by Professor C. E. Munroe on the application of modern explosions. Wednesday, August 23d, was devoted by the botanists to the honor of the famous bryologists, William S. Sullivant and Leo Lesquereux, both of whom had their homes in Columbus. A number of excursions were carried out, one of the most interesting being to the Gas Fields.

The place selected for the meeting of 1900 is New York City and the date set is the last week in June, a radical change which will meet with universal approval. The meeting of 1901 will be held in Denver, Colorado.

The officers nominated for 1900 are as follows :

President: R. S. Woodward, Columbia University.

Vice Presidents: Section A, Asaph Hall, Jr., University of Michigan ; Section B, Ernest Merritt, Cornell University ; Section C, James Lewis Howe, Washington and Lee University ; Section D, J. A. Brashear of Pittsburg ; Section E, J. F. Kemp, Columbia University ; Section F, C. B. Davenport, Harvard University ; Section G, W. Trelease, Missouri Botanical Garden ; Section H, A. W. Butler of Indianapolis ; Section I, C. M. Woodward of Washington University.

Permanent Secretary, L. O. Howard of Washington. General Secretary, Charles Baskerville, University of North Carolina. Treasurer, R. S. Woodward, Columbia University.

* These are printed in full in the issues of Science, commencing with August 25.

The following is a list of papers accepted for reading at the recent meeting:

SECTION A. *Mathematics and Astronomy.*

G. B. HALSTED: Report on progress in non-Euclidean Geometry.

L. E. DICKSON: Report on progress in the theory of linear groups.

CLEVELAND ABBE: Recent progress in theoretical Meteorology.

ASAPH HALL, JR.: The aberration constant from observations of Polaris.

R. W. MCFARLAND: Ancient eclipses and chronology.

H. C. LORD: Some points in the design of a spectroscope.

JOS. V. COLLINS: Note on Grassmann's proof that there can be but two kinds of lineal multiplication of two factors.

G. J. STOKES: The theory of mathematical inference.

J. R. EASTMAN: Recent progress in positional Astronomy.

R. A. FESSENDEN: The determination of the nature of Electricity and Magnetism, including a determination of the density of the ether.

G. A. MILLER: On the commutators of a group.

S. KIMURA: Linear vector functions.

J. WOODBRIDGE DAVIS: Internal forces that generate stellar atmospheres.

T. H. SAFFORD: Practical astronomy during the first half of the present century.

SECTION B. *Physics.*

F. C. CALDWELL: Apparatus for the demonstration of the varying currents in the different conductors of a rotary converter.

H. T. EDDY: A new graphical method of constructing the entropy-temperature diagram from the indicator card of a gas or an oil engine.

WILLIAM HALLOCK: Compound harmonic vibration of a string.

LYMAN J. BRIGGS: A new form of electrical condenser having a capacity capable of continuous adjustment.

J. MCK. CATTELL: Time of perception as a measure of the intensity of light. Relations of time and space in vision.

CHARLES K. WEAD: The musical scales of the Arabs. Medieval organ pipes and their bearing on the history of the scale.

H. S. CARHART and K. E. GUTHE: An absolute determination of the E. M. F. of a Clark cell.

AUGUSTUS TROWBRIDGE: Quantitative investigation of the coherer.

K. E. GUTHE and M. D. ATKINS: Polarization and polarization-capacity.

R. A. FESSENDEN: Current and voltage curves in the magnetically blown arc and in the aluminum electrolytic cell. Some new apparatus—tachometer, chronograph, data collector, induction coil, balance for standardizing amperemeters, standard of induction. Measurement of magnetism in iron and the relation between permeability and hysteresis. Location of smokeless discharge by means of colored screens. Note on the age of the earth.

B. E. MOORE: Polarization and internal resistance of the copper voltameter.

C. A. SKINNER: Concerning the fall of potential at the anode in a Geissler tube.

F. A. WOLFF, JR.: The equipment and facilities of the Office of U. S. Standard Weights and Measures for the verification of electrical standard and measuring apparatus. An experimental test of the accuracy of Ohm's law.

O. L. FASSIG: March Weather in the United States, etc.

D. B. BRACE: A new spectrophotometer and a method of optically calibrating the slit. On achromatic polarization in crystalline combinations.

E. V. CAPPS: Optical calibration of the slit of a spectrometer.

E. J. RENDTORFF: On differential dispersion in double refracting media.

FRED E. KESTER: A method for the study of phosphoresent sulphides.

B. V. HILL: Accidental double refraction in colloids and crystalloids.

C. E. MENDENHALL: A bolometric study of the radiation of a black body between 600° and 1100° C.

F. A. SAUNDERS: A bolometric study of the radiation of an absolute black body.

F. E. NIPHER: On thermodynamic surfaces of P. V. T. for solid, liquid and gaseous state.

S. R. COOK: On the escape of gases from the planets according to the Kinetic Theory. On flutings in Kundt's tube.

J. S. STEVENS: Relation of magnetisation to the modulus of elasticity.

THOS. GRAY: The dielectric strength of oils. Some unexpected errors in watt-meter measurements.

DAVID P. TODD: Note on the preparation of reticles.

E. W. SCRIPTURE: The nature of spoken vowels, with reference to the theories of Helmholtz and Hermann. Electrical anesthesia.

J. F. MOHLER: Pressure and wave-length.

A. WILMER DUFF: The attenuation of sound and the constant of radiation of air.

SECTION C. *Chemistry.*

WILDER D. BANCROFT: The relation of physical Chemistry to technical Chemistry.

WM. MCPHERSON: On the constitution of oxy-azo-compounds.

W. R. WHITNEY: The nature of the change from violet to green in solutions of chromium salts.

J. J. KESSLER, JR.: Micro-structure of antimony-tin alloys.

LOUIS KAHLENBERG: The electrolytic deposition of metals from non-aqueous solutions.

A. A. NOYES: Some experimental illustrations of the electrolytic dissociation theory.

RUDOLF DEROODE: Methods of analysis of sulphite solutions used in paper making.

C. G. HOPKINS: Improvement in the chemical composition of the corn kernel.

H. W. WILEY and W. H. KRUG: Some new products of maize stalks (with illustrative experiments).

E. F. LADD: Soil humus.

J. T. WILLARD: The relation of fertilizers to soil moistures.

THOS. CLARK: Secondary heptylamine.

WM. B. SHOLER: Propane trisulphonic acid.

H. C. BIDDLE: On the derivatives of isnoctive of formhydroxamic acid, and their relation to fulminic acid.

JAS. H. STEBBINS, JR.: The Reichert figure of butter.

GEO. W. SARGENT: The determination of nickel in nickel steel. The quantitative estimation of boric acid in tourmaline.

W. A. NOYES and J. W. SHEPHERD: Camphoric acid, alpha-hydroxy-dihydro-cis-campholytic acid, and the synthesis of dimethyl-cyan-carbon-ethyl-cycle-pentanone.

M. GOMBERG: Diazo-caffeine. The preparation of the tri-phenyl-chlor-methane and tri-phenyl-carbinol.

F. J. POND: The action of sodium methylate upon the dibromides of pro-penyl compounds and unsaturated ketones.

C. C. HOWARD: Some secondary cyclic amines.

WM. MCPHERSON and ROBERT FISCHER: On naphalene-azo-alpha-naphthol and its derivatives.

W. A. NOYES: Esterification experiments with hexa- and tetrahydroxylic acids.

CHARLES BASKERVILLE: On the condensation of chloral with ortho-, meta- and para-nitranilines. Note on the occurrence of chromium, titanium and vanadium in peats. On the universal distribution of titanium.

T. W. RICHARDS: The atomic weight of calcium.

M. E. HILTNER: Preliminary report on a new method for the determination of carbon dioxide.

A. H. GILL: Analysis of oils.

A. S. MITCHELL: Examination of lemon flavoring extracts.

F. W. WOLL: The composition of American and foreign dairy salt.

H. A. WEBER: Notes on testing soils for application of commercial fertilizers.

A. P. SAUNDERS: A determination of the transformation point of sodium sulphate.

F. P. DUNNINGTON: Notes on the estimation of total carbon in iron and steel.

H. M. FERNBERGER and E. F. SMITH: Electrolysis of metallic phosphate solutions.

F. J. POND, O. P. MAXWELL and G. M. NORMAN: The action of sodium methylate upon the dibromides of propenyl compounds and unsaturated ketones.

R. K. MEADE and J. C. ATKINS: On the determination of volatile combustible matter in coke and anthracite coal.

EDGAR F. SMITH: Observations upon tungsten.

W. L. HARZIN: The atomic mass of tungsten. Derivatives and atomic mass of palladium.

M. J. MOORE: Notes on the determination of sulphur in pig iron.

JOSEPH H. JAMES: An electrolytic study of benzoin and benzil.

J. K. HAYWOOD: Some boiling-point curves.

LILY G. KOLLACK: Electrolytic determinations and separations.

J. G. SHENGLE and E. F. SMITH: The precipitation of copper by zinc.

R. W. TUNNELL and E. F. SMITH: Action of hydrochloric acid gas upon sulphates, selenates, tellurates and phosphates.

C. H. CLARKE and E. F. SMITH: The electrolytic oxidation of succinic acid.

A. R. FOSTER and E. F. SMITH: The persulphates of rubidium, cæsium and thallium.

C. A. BROWNE, Jr.: The chemical composition of butter fat The chemistry of rancidity in butter fat.

PAUL MURRILL: Halides and perhalides of the picolines.

SECTION D. *Mechanical Science and Engineering.*

W. T. MAGRUDER: Supports of beams in tests of transverse strength. Crystallization in bronze test pieces. The fracture of spheres.

THOMAS GRAY: The illustration of critical speeds of shafts. The friction of balls in thrust bearings. The fuel value of cereals.

F. C. WAGNER: A novel method of testing a locomotive boiler.

WM. S. ALDRICH: Electric mining of bituminous coal. Some engineering experiences with Spanish wrecks.

W. K. PALMER: A new exact graphical method for designing cone pulleys.

J. W. SHEPHERD: Some experiments on combustion in locomotive boilers.

C. B. MORRISON: Some thermal determinations in heating and ventilating buildings.

A. G. FRIED: Defective vision of school children.

SECTION E. *Geology.**

EDWARD ORTON: The geology of Columbus and vicinity.

FRANK LEVERETT: Glacial phenomena of Central Ohio.

WARREN UPHAM: Glacial and modified drift in Minneapolis, Minn.

G. FREDERICK WRIGHT: Lateral erosion at the mouth of Niagara Gorge.

C. H. HITCHCOCK: The geology of Oahu, Hawaiian Islands.

C. D. WALCOTT: A Pre-Cambrian Upper Algonkian terrane.

W. H. HOBBS and C. K. LEITH: The petrographic province of Fox River Valley, Wisconsin.

A. F. FOERSTE: Age and development of the Cincinnati anticline.

CHARLES SCHUCHERT: The Lower Devonian aspect of the Lower Helderberg and Oriskany formations.

H. S. WILLIAMS: The Silurian-Devonian boundary in North America.

J. J. STEVENSON: The section at Schoharie, N. Y.

JOSEPH LE CONTE: The Ozarkian and its significance in theoretic Geology.

GEORGE H. ASHLEY: The geological results of the Indiana Coal Survey.

J. A HOLMES: The Cape Fear section in the coastal plain.

* Including papers presented before the Geological Society of America.

E. T. DUMBLE: Triassic coal and coke of Sonora, Mexico.

J. H. PRATT: The occurrences of corundum.

J. A. HOLMES: Some geological conditions favoring water-power developments in the South Atlantic region.

JOHN M. CLARKE: *Paropsonema;* a peculiar Echinoderm from the Intumescens Fauna, New York. Remarkable occurrence of Orthoceros in the Oneonta Sandstones of New York. The Squaw Island "Water Biscuit," Canandaigua Lake, New York.

MARY A. FLEMING: The pot holes of Foster's Flats (now called Niagara Glen) on the Niagara River.

W. SIMONDS: A consideration of the interpretation of unusual events in geological records.

W. J. MCGEE: The Pre-Lafayette (Tennessean) base level.

CHAS. E. SLOCUM: The relative ages of the Maumee glacial lake and the Niagara Gorge.

F. B. TAYLOR: The Galt moraine and associated drainage.

E. H. BARBOUR and W. C. KNIGHT: Discovery of new invertebrates in the Dinosaur beds of Wyoming.

E. H. BARBOUR: The rapid decline of geyser activity.

SECTION F. *Zoology.*

C. C. NUTTING: On the utility of phosphorescence in deep sea animals.

B. B. MYERS: The course of the fibres in the optic chiasma of the common American toad, *Bufo lentiginosus.*

HENRY B. WARD: On *Reighardia,* a new genus of Linguatulida.

CARL H. EIGENMANN: Cave animals: their character, origin, and their evidence for or against the transmission of acquired characters.

F. M. WEBSTER: Have we more than a single species of Blissus in North America?

M. BURTON WILLIAMSON: Æstivation of *Epiphragmorphora traskii* (Newcomb) in S. California.

R. W. SCHUFELDT: Natural taxonomy of the class Aves.

SUSANNA P. GAGE: Notes on the morphology of the chick's brain.

SIMON H. GAGE: Further Notes on the Brook Lamprey (*Lampetra wilderi*). Respiration in tadpoles of the toad (*Bufo lentiginosus*). Photographing Natural History specimens under water or other liquids with a vertical camera.

H. C. OBERHOLSE: Geographical variations illustrated by the horned larks of North America.

W. G. JOHNSON: Effects of hydrocyanic acid gas upon animal life and its common use.

C. L. MARLATT: A discussion of *Aspidiotus cydoniæ* and its allies.

B. F. KINGSBURY: The histogenesis of muscle in the metamorphosis of the toad. (*Bufo lentig. Americanus*)

THEO. GILL: The progenitors of Batrachians.

HERBERT OSBORN: Observations on the variation, life-history and habits of a minute locust (*Edipoda maritma Uhl* (?)).

A. D. HOPKINS: A chart for illustrating the origin and evolution of animal and vegetable life.

SECTION G. *Botany.**

F. L. STEVENS: The fertilization of *Albugo bliti.*

FRANCIS RAMALEY: The embryo sac of *Leucocrinum montanum.*

A. S. HITCHCOCK: Notes on subterranean organs.

W. J. BEAL: Some monstrosities in spikelets of Eragostis and Setaria with their meaning.

C. E. BESSEY: Studies of vegetation of the high Nebraska plains. One thousand miles for a fern. Are the trees advancing or retreating upon the Nebraska plains?

* Including also (below) titles of papers presented before the Botanical Club.

WM. SAUNDERS: The breeding of apples for the Northwest plains. Useful trees and shrubs for the Northwest plains of Canada.

BYRON D. HALSTED: Field experiments with "Nitragin" and other germ fertilizers.

A. J. GROUT: Suggestions for a more satisfactory classification of the Pleurocarpous mosses.

BRUCE FINK: Notes concerning the study of lichen distribution in the Mississippi Valley.

W. C. STEVENS: Botanical teaching in the secondary schools.

IDA CLENDENIN: Botanical teaching in the secondary schools.

H. L. BOLLEY: The duration of bacterial existence under trial environments.

H. A. HARDING: The occurrence of the black rot of cabbage in Europe.

W. T. SWINGLE: A summary of our knowledge of the fig.

WM. TRELEASE: The classification of Botanical publications.

E. B. COPELAND: The geotropism of the Hypocotyl of Cucurbits.

A. F. WOODS: The destruction of chlorophyll by oxidizing enzymes.

C. O. TOWNSEND: The effect of hydrocyanic acid gas upon the germination of seeds.

W. G. JOHNSON: Some physiological effects of hydrocyanic acid gas upon plants.

W. B. STEWART: Etiolative reactions of *Sarracenia* and *Oxalis*.

JULIA B. CLIFFORD: The mycorhiza of *Tipularia*.

J. C. ARTHUR: The cultures of *Uredineae* in 1899.

F. E. LLOYD: The embryology of *Vaillantia hispida*.

J. H. SCHAFFNER: Division of the megaspore of *Erythronium*.

IRWIN F. SMITH: The fungous infestations of agricultural soils in the United States.

H. L. BOLLEY and L R. WALDRON: The occurrence of calcium oxalate and lignin during the differentiation of the buds of *Prunus Americana*.

HERMANN VON SCHRENK: Two diseases of *Juniperus*.

HENRY KRAENER: The crystals in *Datura stramonium L*

L. M. UNDERWOOD: What shall we regard as generic types? Summary of our knowledge of the distribution of Fungi in America.

L. C. CORBETT: A device for registering plant growth.

A. D. SELBY: The tamarack swamp in Ohio. The introduced species of Lactuca in Ohio. On *Plasmopara Cubensis*. The flora of Franklin Co, Ohio.

O. F. COOK: Notes on some of the work of the Division of Botany of the U. S. Department of Agriculture.

T. A. WILLIAMS: Some features of the investigations on grasses and forage plants, in charge of the Division of Agristology, U. S. Department of Agriculture.

J. W. T. DUVEL: A brief embryological study of *Lactuca scariola* L.

A. S. HITCHCOCK: Distribution of some Kansas plants. Some wheat crosses.

W. R. LAZENBY: Unusual development of leaves and growth of plants from cuttings.

A. D. HOPKINS: Some botanical notes by an entomologist.

C. E. BESSEY: A greasewood compass plant. A visit to the original station of the Rydberg cottonwood. The wilting of *Cleome integrifolia*. The powdery mildew of *Polygonium aviculare*.

N. L. BRITTON: Report on Mr. Heller's Botanical Exploration of Porto Rico. Notes on the northern species of Celtis. Remarks on some species of Quercus.

F. S. EARLE: Tomato fruit rot.

W. J. BEAL: Botanical Club of the Michigan Agricultural College. The introduction of *Cabomba Caroliniana* in Michigan.

W. SAUNDERS: The Arboretum and Botanic Garden of the Central Experiment Farms, Ottawa, Canada.

F. E. LLOYD: Two hitherto confused species of Lycopodium.

W. A. KELLERMAN: Ohio sections for Lea's oak. Labels for living plants

SECTION H. *Anthropology.*

W. J. McGEE: The beginnings of Mathematics.

J. McK. CATTELL: The scientific societies and institutions of the United States. New anthropometric methods. Report of committee on White Race in America.

In Memoriam—Dr. Daniel G. Brinton.

E. W. SCRIPTURE: Researches in experimental phonetics, with demonstration of results. Inadequacy of the present tests for color-blindness, with demonstrations of a new test. Observations on after-images and cerebral light. Observations on the economy of sleep.

C. E. SLOCUM: Regarding the evidences of ancient prehistoric man in the Maumee River Basin.

G. FREDERICK WRIGHT: The latest discoveries of traces of glacial man at Trenton, N. J., and the light thrown upon them by a comparative study of the gravels of the Delaware and Susquehanna Valleys.

THOS. WILSON: Recollections of M. Bourcher de Perthes.

W. A. PHILLIPS: The aboriginal quarries and shops at Mill Creek, Miami Co., Ill.

CHARLES K. WEAD: The national diatonic scale: a chapter of musical history.

ROBERT STEINER: Allan Stevenson's trance. Prehistoric settlement, Big Kiokee Creek, Columbia Co., Ga.

FRANK RUSSELL: A comparative study of the physical structure of the Labrador Eskimos and the New England Indians, illustrated by lantern slides.

JAMES MOONEY: The Cherokee River cult.

GEORGE G. MCCURDY: Extent of instruction in Anthropology in Europe and America.

ELIZA T. HOUK: Evolution.

SECTION I. *Social and Economic Science.*

JOHN HYDE: Natural distribution as modified by modern agriculture.

CORA A. BENNESON: Federal guarantees for maintaining Republican governments in the States.

HENRY FARQUHAR: Calculations of populations in June, 1890.

FLORENCE KELLEY: Power of the consumer economically considered.

M. A. CLANCY: The basis of war and peace.

MANSFIELD MERRIMAN: The increase in the median age of the population of the United States since 1850

WASHINGTON GLADDEN: Moral tendencies of existing social conditions.

R. A. FESSENDEN: Hysteresis in social, economic and vital phenomena.

JOHN S. CLARK: Science and art in social development.

LAURA OSBORNE TALBOTT: The personal equation as a psychological factor.

DANIEL FOLKMAR: Positive science and methods in education.

T. M. BALLIET: Some new aspects of educational thought.

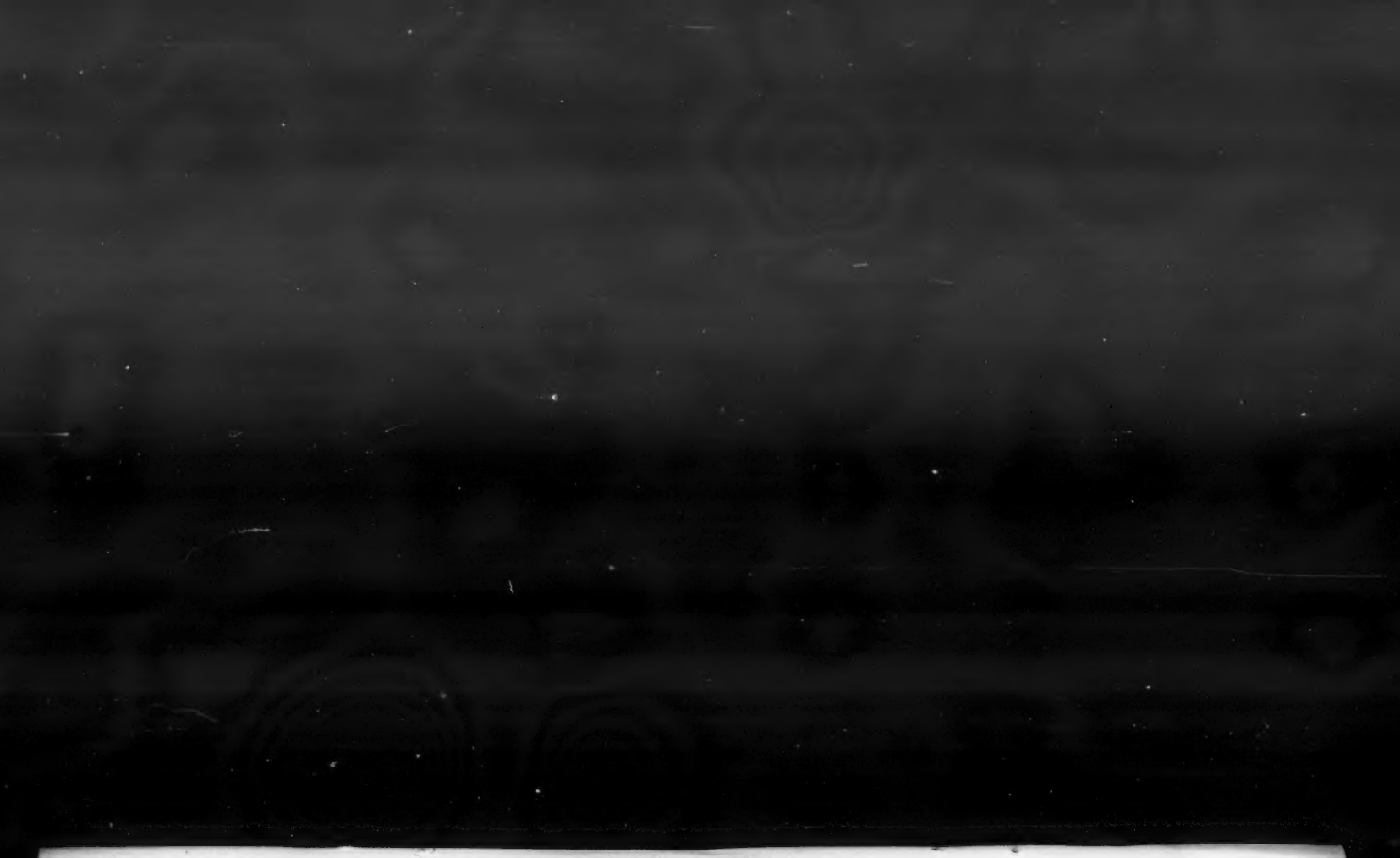
C. M. WOODWARD: The manual element in education.

H. T. NEWCOMB: The spoils system in theory and practice. Trusts: A study in industrial evolution.

OBITUARY.

Professor ROBERT WILHELM BUNSEN, the veteran German chemist, died in Heidelberg on the 16th of August last at the age of eighty-eight. Of what he accomplished for science during his long period of active service, only brought to a close by the infirmities of great age, chemists and physicists hardly need to be informed—with the founding of the department of spectrum analysis and the development of the methods of gas analysis, his name will be ever as surely connected as it is in popular use with the "Bunsen burner." But to those who enjoyed the privilege of working under him, of learning to know personally as well as to come into somewhat close contact with his keen mind, his death comes as a direct personal loss. This is so well expressed by a gifted chemist* in a recent number of Nature that no apology is needed for quoting his words here: . . . "But this experimental work, great and important as it is, is not the greatest or most important work that he accomplished. It is as a teacher and as an example that the name of Bunsen is and will be chiefly honored and remembered. It is only those who have had the benefit of working under and with him who can fully understand the feelings of affection and respect with which they regard his memory. To those who had the privilege of his intimacy, of whom I can happily claim to be one, his friendship will remain as an abiding source of gratification. As an investigator he was great, as a teacher he was greater, as a man and a friend he was greatest."

SIR EDWARD FRANKLAND, the distinguished English chemist, died on the 9th of August in his seventy-fifth year. A recent writer says of him, his "title to fame rests securely upon his important experimental investigations in pure chemistry, accomplished chiefly within the twenty years from 1848 to 1868, and upon the impetus which was given to theoretical chemistry by the promulgation of his views concerning the combining capacity, or valency as it is now called, of the elements, which he derived from the results of his experimental work."

DR. DANIEL GARRISON BRINTON of Philadelphia, the distinguished and learned anthropologist, died on July 31st in his sixty-third year. He held for many years the Professorship of American Archæology and Linguistics in the University of Pennsylvania. His contributions to science, particularly in the line of the languages of the original tribes of North America, were numerous and of great value.

*Sir Henry E. Roscoe in Nature for August 31. The same writer gave an admirable account of Bunsen's life and work some eighteen years since in vol. xxiii of Nature's Series of Science Worthies.